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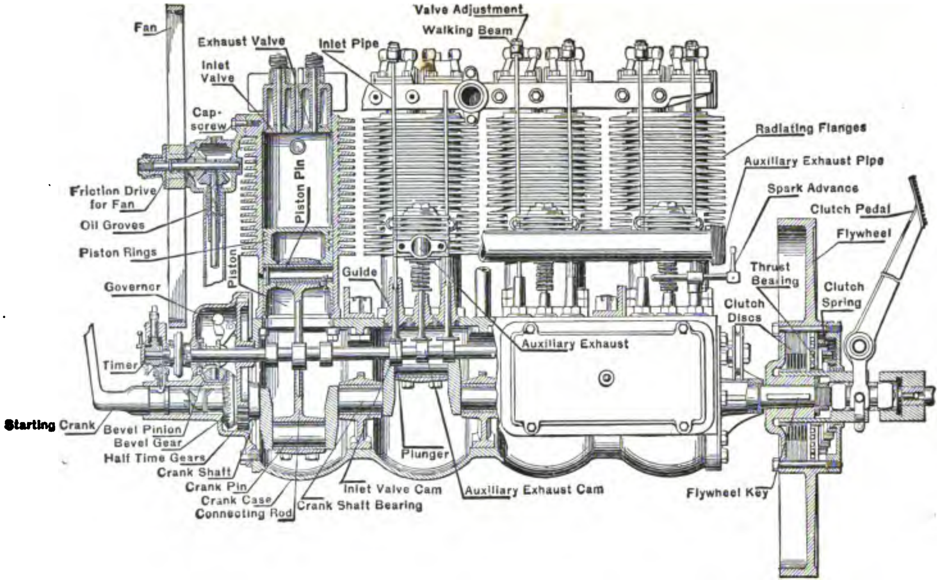

Frontispiece.

THE COMPLETE
AUTOMOBILE INSTRUCTOR

OVER SIX HUNDRED QUESTIONS WITH
ANSWERS AND ILLUSTRATIONS, COVERING
THE PRINCIPLE, THE OPERATION, AND
THE CARE OF GASOLINE AUTOMOBILES

BY

BENJAMIN R. TILLSON
Director of the H. J. Willard Co. Automobile School

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PREFACE

THE title of this work is open to criticism as to the completeness of the instruction, and the author realizes that the "tale is not half told"; but if the book is a stepping-stone to further study it has accomplished its object.

To the reader who is operating his first car a perusal of this little volume will throw light upon many perplexing problems he may have to deal with in the operation and enjoyment of the automobile.

To the student who contemplates entering the automobile business this work, it need hardly be said, is especially adapted.

To the salesman it will be a great help in mastering the principles of design, construction, operation, and care of automobiles: and who is better able to sell than one who understands his goods?

To the dealer in automobiles the book will lessen the time necessary to instruct the new customer, and through a better understanding of the principle of operation by the latter better service will be got from the machine, which will result in reducing the customer's chance of claims against the dealer, whose profit and time are thus conserved.

To the repairman it will be invaluable, for, coupled with his knowledge of mechanics, it will enable him to grasp the principle of automobile mechanism more readily.

To the manufacturer it will prove of great benefit by securing from buyers intelligent operation and care of his product, which will result in greater satisfaction being given by his cars, and longer life for them, while lessening the number of claims for defective parts which are in a great many instances caused by misuse and abuse due to the inexperience and lack of knowledge of the owner.

To the prospective purchaser a study of this work is desirable in enabling him to secure an automobile best suited to his requirements and familiarizing him with the mechanism to such an extent that the "bluff" of a salesman is recognized readily and the car is bought on judgment, not by persuasion.

A word about the arrangement of this work and its adaptability for reference. Arranged in question-and-answer form, the questions are given in a body, grouped under appropriate heads, in the first part of the book, the answers, similarly grouped, following. A note on each page refers the reader to the answers to the questions, or to the questions to the answers, he is reading.

The answers explain in each case the questions involved, without the catechism result, and are arranged consecutively. The subjects are classified under a table of contents, and one in search of general information on one subject can turn directly to it.

An index for reference to any information sought, and a list of illustrations, make it a handy help to the man whose time is limited and valuable.

THE AUTHOR.

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QUESTIONS

PARTS OF A MOTOR.

(For answers to questions on this page, see pp. 47–52.)

1. What is the cylinder?
2. What is the piston?
3. What is the piston-pin?
4. What is the connecting-rod?
5. What is the crank-shaft?
6. What is the crank-pin?
7. What is the fly-wheel?
8. What is the combustion-chamber?
9. What is the inlet-valve?
10. What is the exhaust-valve?
11. What is the valve-stem?
12. What is the cam?
13. Where is the cam placed?
14. What is the cam-shaft and its use?
15. What are the two-to-one gears?
16. What is the push-rod?
17. What is the crank-case?
18. What is the spark-plug?
19. What are the packing-rings?
20. What is the governor and its use?
21. What is the timer and its use?
22. What is a gasket?
23. What is the inlet-pipe?

(For answers to questions on this page, see pp. 52–56.)

24. What is the exhaust-pipe?

25. What is the muffler?

26. What is a bushing?

27. What is a multiple engine?

28. What are piston-rings?

29. What is a compression relief-cock or pet-cock?

30. What is a bell-crank?

31. What is an eccentric?

32. What is an auxiliary exhaust-valve?

33. What is a spring-cotter?

34. What is a lock-nut?

35. What is a cap-screw?

36. What is a stud-bolt?

37. What is a set-screw?

38. What are liners, shims, or distance-washers?

39. What is a key or feather (Woodruff patent, taper, and straight)?

40. What is a check-valve?

41. What is a relief-valve?

42. What is a spider?

43. What is a clevis?

44. What is a turnbuckle?

45. What is a union?

46. What is a stuffing-nut?

47. What is a diaphragm?

48. What is a walking-beam?

49. What is an apron or under-cover?

(For answers to questions on this page, see pp. 56–59.)

50. What is a sprocket?
51. What is a jack-shaft?
52. What is a solid rear axle?
53. What is a divided rear axle?
54. What is the floating type of rear axle?
55. What is a transmission-brake?
56. What is a brake-shoe?
57. What is a brake-drum?
58. What is a cone clutch?
59. What is an expanding clutch?
60. What is a multiple disk clutch?
61. What is a contractional clutch?
62. What is an idler or intermediate gear?
63. What is a silent gear?
64. What is a rack-gear?
65. What is a worm-gear?
66. What is a worm?
67. What is a pinion-gear?
68. What is a spur-gear?
69. What are bevel-gears?
70. What are mitre-gears?
71. What is a thrust-bearing?
72. What are Hess-Bright bearings?
73. What is a cylinder-jacket (water-jacket)?
74. What is a drain-cock?
75. What is a stand-pipe?
76. What is a compression grease-cup?

TWO-CYCLE MOTORS

(For answers to questions on this page, see pp. 60–64.)

1. How many systems of two-cycle motors are in general use for automobiles?

2. What is a two-port type of two-cycle motor?

3. What is a three-port type of two-cycle motor?

4. How does the two-cycle motor operate?

5. What provision is made to prevent the fresh charge of gas from escaping through the exhaust before the exhaust-port is closed?

6. What is a by-pass?

7. What is done to prevent explosions in the crank-chamber?

8. How many pounds compression are there in the crank-chamber approximately?

9. How many pounds compression are there in the cylinder approximately?

10. Why does a two-cycle motor miss explosions when throttled?

11. How is the compression in the crank-case of a two-cycle motor prevented from escaping through the crank-shaft bearings?

12. What causes explosions in the crank-case?

13. Will a two-cycle motor run in either direction?

14. What would cause a two-cycle motor to run in the reverse direction?

(For answers to questions on this page, see pp. 64–66.)

15. Can a two-cycle motor be reversed while running?

16. Can a two-cycle motor be reversed with any certainty?

17. How is the timer attached on a two-cycle motor?

18. How many revolutions of the crank-shaft are necessary for one power stroke of a two-cycle motor?

FOUR-CYCLE MOTORS

1. What is meant by the word cycle as applied to gas-engines?

2. How many revolutions of the crank-shaft are necessary for each power impulse?

3. What are the four actions of a four-cycle gasoline-motor?

4. What action takes place first in the four-cycle motor?

5. How is the fuel or explosive gas admitted to the cylinder?

6. After the gasoline mixture has been admitted to the cylinder what action takes place?

7. After the gas has been compressed what occurs?

8. Having ignited the gasoline mixture, how is the piston forced out of the cylinder?

(For answers to questions on this page, see pp. 66–68.)

9. What is the action of the motor in discharging the burned gases?

10. At what part of the stroke should the igintion take place?

11. At what part of the piston-stroke should the gas be admitted?

12. At what part of the stroke should the exhaust take place?

13. About how many pounds compression are there in the cylinder of a gas-motor?

14. Can the direction of rotation be changed in a four-cycle motor?

VALVES

1. What two kinds of inlet-valves are used in a gas-motor?

2. How is an automatic inlet-valve opened and how closed?

3. What effect would increasing the spring tension on an automatic valve have?

4. Why cannot an automatic valve be used for the exhaust?

5. Do multiple engines always have mechanical inlet-valves?

6. How is a mechanical valve operated?

7. How many revolutions of the crank-shaft are there to one of the cam?

(For answers to questions on this page, see pp. 68-71.)

8 What are some of the disadvantages of an automatic inlet-valve?

9. What are some of the advantages of a mechanically operated inlet-valve?

10. When should the inlet-valve open on a four-cycle motor?

11. When should the inlet-valve close on a four-cycle motor?

12. When should the exhaust-valve open on a four-cycle motor?

13. When should the exhaust-valve close on a four-cycle motor?

14. How can the valves be timed without specific instructions from the manufacturer?

15. How is the exhaust-valve opened?

16. How is the exhaust-valve closed?

17. What would happen if the exhaust-valve did not open at the proper time?

18. What would happen if the exhaust-valve failed to close?

19. Valves opening early and closing late indicate what?

20. Valves opening late and closing early indicate what?

21. Valves opening early and closing early indicate what?

22. What effect would a loose cam on the shaft have?

23. In the seating of valves when the engine is cold what allowance should be made?

(For answers to questions on this page, see pp. 71–73.)

24. What is the effect of turning a valve round and round when grinding?

25. What is the proper way to grind a valve?

26. Why do valves have to be ground?

27. What might cause an exhaust-valve to stick?

28. What would be the effect of the valve sticking?

29. How could sticking of the exhaust-valve be remedied?

30. What effect would a weak exhaust-valve spring have?

31. What effect would a pitted valve have?

32. What effect would a valve have that had been improperly ground, having ridges or grooves in its seat?

33. Of what value is filling the valve with gasoline to test its seat?

34. How can we tell when a valve is ground properly?

35. What should be done when valves have been ground several times?

36. What causes a valve-stem to bend?

37. How is it possible to tell when the exhaust-valves need grinding?

38. What can be done if a valve-stem is too short?

COOLING

(For answers to questions on this page, see pp. 73–80.)

1. Why is a gasoline-motor cooled?

2. What is the effect of heat upon the power of a gasoline-motor?

3. What is the object of cooling a motor?

4. How many systems of cooling automobile-motors are used?

5. How many methods of cooling by water are there?

6. How many methods of cooling by air are there?

7. What is the purpose of a fan on air- and water-cooled cars?

8. Of what benefit is a fan when traveling at high speed?

9. What precaution should be taken to prevent the formation of air-pockets in the cooling system?

10. If an air-pocket was formed what would be the result?

11. How is an air-pocket in the circulating system indicated?

12. Should the gear which drives the pump become loose or the pump refuse to work, what should be done?

13. How many styles of pumps are used?

14. What are some of the advantages of air-cooling?

(For answers to questions on this page, see pp. 80–82.)

15. What should be done to prevent freezing of the water in winter?

16. How often should the cooling system be drained?

CARBURETORS

1. What is the chemical composition of gasoline?

2. What is the function of the carburetor?

3. What is the proportion of gasoline in the mixture?

4. Why is air mixed with gasoline?

5. What two systems of carburetors are in general use?

6. Where does the gasoline from the tank enter the carburetor?

7. How many kinds of floats are generally used?

8. What kinds of floats are used?

9. What can be used for a float in emergencies?

10. How is the height of gasoline regulated?

11. When the gasoline rises to a sufficient height how is the supply cut off?

12. How is the spray-nozzle connected to the float-chamber?

13. Where is the spray-nozzle located?

(For answers to questions on this page, see pp. 82–87.)

14. What is the correct height to which the gasoline should rise in the spray-nozzle?

15. In what form is the gasoline drawn from the spray-nozzle?

16. What is meant by the quality of the mixture?

17. Upon what does the quality of the gas depend?

18. How is the quality of the gas obtained by gasoline adjustment?

19. How is the quality of the gas obtained by air adjustment?

20. Can the air be adjusted while running?

21. What effect upon the suction has the speed of the engine?

22. What method is employed to keep the quality of gas uniform?

23. How is the opening of the auxiliary air-valve controlled?

24. What opens the auxiliary air-valve?

25. When is the auxiliary air-valve used?

26. What adjustments are provided for the auxiliary air-valve?

27. What effect does the height of gasoline have upon the carburetor adjustment?

28. When the gasoline level is too low what is the result?

29. How is the float-feed carburetor primed?

30. What effect has a restricted flow of gasoline to the spray-nozzle upon high speed?

(For answers to questions on this page, see pp. 87–90).

31. What indicates a too rich mixture?

32. What indicates a too weak mixture?

33. What should be kept in mind when adjusting a carburetor?

34. What kind of carburetors are called mixing-valves?

35. How is the gasoline drawn in the case of a mixing-valve?

36. How is the gasoline vaporized?

37. How is the mixing-valve carburetor adjusted?

38. Why must a mixing-valve be primed before starting?

39. How is the mixing-valve primed?

40. Why is the mixing-valve not used extensively on automobiles?

41. How can the mixing-valve be constructed to spray the gasoline?

42. In the greater number of American automobiles how is the gasoline fed to the carburetor?

43. When the tank is lower than the carburetor how is the gasoline raised to the carburetor?

44. How is the pressure obtained to raise the gasoline to the carburetor?

45. Why does the exhaust not set the gasoline on fire?

46. What disadvantages has the exhaust pressure system?

(For answers to questions on this page, see pp. 90–93.)

47. About how much pressure is required to raise gasoline from the tank to the carburetor?

48. How can a car having a low tank be started without pressure therein?

49. How should the gasoline be strained?

COILS

1. How many kinds of spark-coils are used on automobiles?

2. Of what does a coil as used in the low-tension or make-and-break system consist?

3. Of what does an induction or Ruhmkorff coil used on the jump-spark or high-tension system consist?

4. How many systems of induction-coils are there?

5. Why is the primary winding made of coarse wire?

6. Why is the resistance of the secondary winding of little concern?

7. What causes a current in the secondary winding of an induction-coil?

8. Are the primary and secondary windings insulated from each other, and why is insulation important?

9. How is the core constructed?

(For answers to questions on this page, see pp. 93–98.)

10. What is self-induction?

11. What is a condenser?

12. What is the object of the condenser?

13. What is the operation of an induction-coil?

14. Upon what does the current strength of the secondary winding depend?

15. What is the best voltage of battery current for a spark-coil?

16. What is the voltage of the primary winding of the coil?

17. What is the voltage of the secondary current?

18. What is the amperage of the primary current?

19. What is the amperage of the secondary current?

20. What is a vibrator?

21. What does excessive sparking at the vibrator-points denote?

22. What would be the effect of a self-induced current were it not absorbed by the condenser?

23. Can a coil be adjusted correctly by the sound of the vibrator?

24. How can an ammeter be connected in circuit to show the current consumption of a coil?

25. What is the correct way to adjust a vibrator?

26. What is the effect of causing the second-

(For answers to questions on this page, see pp. 98–104.)

ary spark to jump the greatest distance possible?

27. How many coils are generally used on a four-cylinder car?

28. Can less than four coils be used to ignite a four-cylinder car?

29. Is a vibrator necessary in the jump-spark system?

TIMERS

1. What is the object of the timer?

2. What are the different kinds of contact called?

3. What is the touch or make-and-break timer?

4. What is the roller-contact timer?

5. What is the sliding-contact timer?

6. What is the brush-contact timer?

7. Why is the adjustable contact-timer best?

8. What part of the timer is the commutator?

9. What effect has a worn timer at high speeds?

10. What effect has a lubricant on the timer?

11. How can the timer ground be improved?

12. How is a four-cylinder motor started "on spark"?

13. What is meant by neutral position of the spark-lever?

(For answers to questions on this page, see pp. 104–107.)

14. How is a timer set on a four-cycle motor?

15. What difference does speed make to the electrical connections and current?

LOW-TENSION IGNITION

1. Why is one system of ignition called low-tension?

2. From what source may a low-tension current be derived?

3. Can the low-tension current be either alternating or direct?

4. Is a spark-coil necessary in a low-tension system?

5. What method is employed to introduce the spark within the cylinder?

6. How is the spark produced?

7. What causes the spark when the points are separated?

8. What metals are used for contact-points?

9. What effect has a long duration of contact on the batteries?

10. When should the contact-points separate?

11. Why is a magneto better for low-tension ignition than batteries?

12. What two points are desired and obtained by the actuating mechanism in this system?

(For answers to questions on this page, see pp. 107–110.)

13. Describe a simple form of low-tension actuating mechanism.

14. Describe another method.

15. Why is the insulation of the electrode more easily maintained in this system than in the jump-spark system?

16. How is the spark timed?

17. How is the spark advanced?

18. Does the lag of magneto-generated current have any effect upon the spark when advanced?

19. What would be the result if one sparker of a multicylinder engine remained in contact?

20. How is a multicylinder engine wired?

MAGNETOS

1. What is the difference between a magneto and a dynamo?

2. How are permanent magnets made?

3. Why do magnets lose their strength?

4. How can you tell if the magnets of the magneto are losing their strength?

5. Can a permanent magnet be remagnetized?

6. Why must the current be applied in a certain direction in remagnetizing permanent magnets?

7. How can the proper direction of current be ascertained?

(For answers to questions on this page, see pp. 111–113.)

8. What two kinds of electrical currents are used on automobiles?

9. What kind of current does a magneto usually give?

10. What kind of current does a dynamo usually give?

11. Can a magneto be made to give a direct current, or a dynamo an alternating current?

12. What is a commutator?

13. What is an armature?

14. What is an electrical field?

15. What are lines of force?

16. How is an electrical current generated by a magneto?

17. At what speed should a magneto be run?

18. Does it matter in which direction a magneto runs?

19. At what point in the rotation of the armature should the interruption of the circuit occur?

20. Upon what does the strength of current generated by a magneto depend?

21. Why is the position of the armature changed with relation to the crank-shaft when it is desired to advance the spark?

22. Running a magneto on open circuit has what effect?

23. What is a low-tension magneto?

24. What is a high-tension magneto?

(For answers to questions on this page, see pp. 113–117.)

25. Can a low-tension magneto be used for a jump-spark system?

26. Why is it advisable not to use a vibrating coil with a magneto?

27. How can a magneto having a stationary armature and magnets give a current?

28. What is a shuttle-type armature?

29. With a magneto is a coil necessary on machines using make-and-break sparking devices?

DRY BATTERIES

1. Of what are dry cells composed?

2. What is a cell?

3. What is a battery?

4. What is a series connection?

5. What does a series connection add?

6. What is a multiple or parallel connection?

7. What does a multiple or parallel connection add?

8. Does series connection add the amperage as well as the voltage of each cell?

9. Why must the voltage of two cells or sets of cells be equal in order to connect in multiple?

10. How should eight cells be connected to give six volts?

11. How could twenty-four cells be connected to give six volts?

(For answers to questions on this page, see pp. 117–119.)

12. How many volts are necessary to operate a coil?

13. Can too many dry cells be used in series?

14. What is the advantage of multiple connection?

15. How can the life of dry cells be prolonged?

16. What kind of switches are used when more than one set of batteries are used?

17. What is the voltage of a dry cell when new?

18. What is the amperage of a dry cell when new?

19. What is the lowest amperage at which a dry cell can be used successfully?

20. How are dry cells tested?

21. Why is a voltmeter not used in testing dry cells?

22. Why do dry cells deteriorate when not in use?

23. What is an emergency dry cell?

24. What effect has moisture on dry cells?

25. Why should heavy copper wire not be used to connect dry cells together?

26. What is the best method of keeping connections tight?

27. Why is the negative side of the battery grounded to the frame of the motor?

STORAGE-BATTERY

(For answers to questions on this page, see pp. 119–123.)

1. What is a storage-battery or accumulator?

2. What types of storage-batteries are in general use?

3. Of what is a storage-cell composed?

4. Of what is the electrolyte composed?

5. How are water and acid mixed to form the electrolyte?

6. How much electrolyte should be in the battery at all times?

7. When should electrolyte be added to a battery?

8. What is the specific gravity of the electrolyte based upon?

9. How is the specific gravity of the electrolyte tested?

10. What is a hydrometer?

11. How is a hydrometer test of the electrolyte made?

12. What is the specific gravity of the electrolyte in a new battery before the first charge?

13. What specific gravity electrolyte should be added to a battery in order to raise the specific gravity of the electrolyte already in the battery?

14. How does the specific gravity of liquids compare with the Baumé gauge?

(For answers to questions on this page, see pp. 123–127.)

15. What should the specific gravity of the electrolyte be when the battery is fully charged?

16. Can the amount of charge remaining in the battery be determined?

17. How is the amount of charge remaining in a battery determined by specific gravity test?

18. What is the action of the first charge of a storage-battery?

19. What is the action of a discharge of a storage-battery?

20. What should be the direction of current in charging?

21. What is the direction of current when discharging?

22. In charging a battery what voltage is necessary?

23. Can any kind of a current be used to charge a storage-battery?

24. What would be the result of charging in the wrong direction?

25. How can the polarity of the charging wire be determined?

26. What is the best current for charging a storage-battery?

27. At what rate should the first part of the charge be put into a storage-battery?

28. What is the maximum charging rate?

29. What injury will result from charging at a high rate?

(For answers to questions on this page, see pp. 127–130.)

30. What should be the charging rate of a new battery?

31. How often should a storage-battery be charged?

32. How often should a storage-battery be discharged?

33. What is the result of always keeping a storage-battery fully charged?

34. How can a discharge be accomplished?

35. What causes sulphating of the plates?

36. How can sulphating of the plates be remedied?

37. What should be the color of the plates in a healthy battery?

38. What indicates that a battery is fully charged?

39. What other way indicates a battery is fully charged?

40. When should electrolyte be added to a battery?

41. Should pure acid ever be added to the electrolyte in a battery?

42. What should be the temperature of a battery while charging?

43. What should be done to let the gas escape while a battery is charging?

44. What danger from explosions should be guarded against?

45. Of what value is a voltmeter test of an idle battery?

(For answers to questions on this page, see pp. 130–133.)

46. Upon what does the amperage of a single cell depend?

47. What is a voltmeter?

48. What is an ammeter?

49. How can a correct voltmeter reading be taken?

50. What is the normal output of a battery?

51. What is the ampere-hour capacity of a battery?

52. Upon what does the ampere-hour capacity of a battery depend?

53. Can a storage-battery be tested with an ammeter?

54. What causes the corrosion of battery terminals?

55. How can the corrosion of battery terminals be prevented?

56. What is the best means of removing a nut from a corroded battery terminal?

57. How should connections between cells be made?

LUBRICATION

1. What is the object of lubricating-oil on a bearing?

2. What indicates lack of lubrication?

3. What effect has overlubrication of a bearing?

(For answers to questions on this page, see pp. 133–138.)

4. What is the effect of overlubrication in the cylinder?

5. What are the essential qualities of a lubricant for gas-engine use?

6. What kinds of lubricators are used?

7. What are the different methods of adjusting the lubricator?

8. What is the effect of lack of lubrication?

9. Should a bearing become hot through lack of lubrication, would its removal be necessary to remedy the trouble?

10. Where does a bearing commence to cut through lack of lubrication?

11. Should a connecting-rod or similar bearing become cut, what would be the remedy?

12. Why are soft-metal bearings used against steel?

13. How often should front wheels be lubricated?

14. How often should the differential gears be lubricated?

15. What kind of oil should be used for the change-speed gear?

16. About how often should the different parts of a car be lubricated?

17. About how many drops of oil should the cylinder receive in a minute?

18. What treatment should the crank-case, transmission-case, and differential case receive?

(For answers to questions on this page, see pp. 138–142.)

19. Why should not gasoline be used to wash out the crank-case, etc.

20. What change should be made in the oil used in cold weather?

21. What parts may be lubricated with grease?

22. What are the different kinds of compression grease-cups?

23. What precaution should be taken in the case of a multiple-disk clutch?

24. How should the cone clutch be lubricated or treated?

25. If the clutch is overlubricated and slips, what is the remedy?

GOVERNORS

1. What is the governor for?

2. How is the speed controlled?

3. What is an accelerator?

4. How many kinds of governors are in general use on automobiles?

5. What is a centrifugal governor?

6. What is a pump-governor?

7. How can the cooling-water act as a governor?

8. Do all governors act upon and regulate the admission of gas to the cylinders in automobile engines?

(For answers to questions on this page, see pp. 143–146.)

9. How is an engine governed by compressed air?

10. How is the amount of gas admitted to the cylinders controlled by compressed air?

11. How is the governor under control of the operator?

12. When the load is suddenly thrown off the engine what is the action of the governor?

13. What is the action of a governor upon ascending a hill or traveling over a stretch of sandy road requiring more power?

14. Of what benefit is the governor when traveling crowded noisy streets?

15. Why are governors usually encased?

16. How is a centrifugal governor operated?

MUFFLERS

1. What is the muffler for?

2. What three things will silence the noise of exhaust?

3. What is meant by an expanding muffler?

4. What is meant by a separating muffler?

5. What is a cooling-muffler?

6. What is the muffler cut-out?

7. Why does the motor give more power when the muffler is cut out?

8. What does back pressure mean?

(For answers to questions on this page, see pp. 146–149.)

9. What effect will a partially stopped opening in the muffler have?

10. What indicates that a muffler is plugged up?

11. What causes an explosion in the muffler?

12. What harm does an explosion in the muffler do?

13. What does black smoke emitted from the muffler indicate?

TRANSMISSION

1. What is a planetary transmission?

2. With a planetary transmission how is the slow speed obtained?

3. With a planetary transmission how is the reverse obtained?

4. With a planetary transmission how is the high gear obtained?

5. How many speeds forward are usually obtained from a planetary transmission?

6. Can a planetary transmission have more than two speeds forward?

7. Can the reverse be used as a brake on a planetary transmission?

8. What is an individual clutch transmission?

9. With an individual clutch transmission how is the slow speed obtained?

(For answers to questions on this page, see pp. 149–153.)

10. With an individual clutch transmission how is the reverse obtained?

11. With an individual clutch transmission how is the high speed obtained?

12. With an individual clutch transmission can the reverse be used as a brake?

13. What is a sliding-gear transmission?

14. With a sliding-gear transmission how is the slow speed obtained?

15. With a sliding-gear transmission how is the second speed obtained?

16. With a sliding-gear transmission how is high gear obtained?

17. With a sliding-gear transmission how can the reverse be obtained?

18. With a sliding-gear transmission can the reverse be used as a brake?

19. What precautions are necessary in using a sliding-gear transmission?

20. What is liable to strip (break the teeth of) the gears?

21. What is the meaning of direct drive on high gear?

22. What is the selective type of sliding-gear transmission?

23. In changing from slow to second speed what is necessary?

24. In changing from high speed to second speed what is necessary?

(For answers to questions on this page, see pp. 153–155.)

25. In reversing a sliding-gear car what precautions are necessary?

26. In ascending a hill on low gear at what speed should the engine be run?

27. Is it good practice to coast with a heavy car?

28. What is a friction drive?

29. Why does a friction drive wear quickly?

CLUTCHES

1. What is a clutch?
2. How many kinds of clutches are used?
3. Describe the different clutches?
4. Where is the clutch placed?
5. How is the clutch operated?
6. When the clutch is engaged is it necessary to hold it from disengaging?
7. Is it necessary to hold the clutch out when starting the engine to prevent the car from starting?
8. When the emergency brake is set is the clutch held out of engagement?
9. Should the operator be able to apply the brake while the clutch is engaged?
10. What precautions are necessary in engaging a clutch?

(For answers to questions on this page, see pp. 155–158.)

11. If a clutch of the cone variety takes hold too quickly what is the remedy?

12. Should a cone clutch slip what is the remedy?

13. What harm does a slipping clutch do?

14. What means are provided for adjusting clutches?

15. Should a clutch be adjusted so tight that it could not be fully released, what would be the effect?

16. What is necessary to the proper working of a metal multiple-disk clutch?

17. What is the principle upon which the multiple-disk clutch operates?

18. Why must a strong spring be used on a multiple-disk clutch?

19. How does the multiple-disk clutch start a car gently?

20. What effect has cold weather on a clutch?

21. How should the oil in the clutch be treated in cold weather?

22. How full should the case of a multiple-disk clutch be filled with oil?

DIFFERENTIALS

1. What is a differential-gear set?

2. How many kinds of differentials are there?

(For answers to questions on this page, see pp. 158-161.)

3. What is the difference between the differential of a chain-driven car and that of a shaft-driven car?

4. What is the difference between a bevel-gear differential and a spur-gear differential?

5. What is the outer case of a differential and its purpose?

6. What is the differential-case and its purpose?

7. To what is the sprocket or driving gear attached?

8. How many bevel-pinions are inside the differential-case of a bevel-gear differential?

9. With what gears do the bevel-pinions of a differential mesh?

10. Why are three or more pinions used?

11. When a car is traveling in a straight line how is the power transmitted through the differential?

12. When making a turn what causes one wheel to move faster than the other?

13. How many spur-pinions are generally used in a spur-gear differential?

14. Why is it necessary to have spur-pinions run in pairs?

15. To what are the spur-gears attached?

16. Should one wheel be prevented from turning, how fast would the other wheel turn?

17. What wheel is driven in turning curves?

18. Why, when both wheels are raised from

(For answers to questions on this page, see pp. 161–168.)

the floor and one wheel is turned, does the other turn in the opposite direction?

19. How can the action of the differential be illustrated?

20. When is the differential in motion?

TIRES

1. How are clincher casings made?
2. How are inner tubes made?
3. What is meant by vulcanizing?
4. What is meant by acid vulcanizing?
5. What part of a tire is called the shoe?
6. What is retreading a tire?
7. How can you determine if retreading a tire will be economical?
8. What is the result of too little pressure in a tire?
9. What is the objection to overinflation of tires?
10. What is the cause of rim cutting?
11. How should tire-rims be cared for?
12. What causes heating of tires?
13. How can the pressure in tires be gauged?
14. How is the best pressure to be used on tires determined?
15. What is an indication that the tires are properly inflated?

(For answers to questions on this page, see pp. 168–173.)

16. What is a quick test of tire inflation?

17. What causes blisters on tires?

18. How should cuts and bruises on the outer casing of a tire be attended to?

19. What causes separation of the fabric?

20. What is a stone-bruise?

21. What is the effect of fractured fabric upon the inner tube?

22. What is frictioned duck?

23. What is the mileage of tires?

24. How can the wear of tires be diminished?

25. What effect does the action of a fierce clutch have on tires?

26. What effect does running on a deflated tire have?

27. What is a blow-out?

28. What causes blow-outs?

29. How should spare tubes be carried?

30. Should the tire-valve leak slowly what should be done?

31. Should the rubber washer in the cap become lost what should be done?

32. How should a valve be tested for leaks?

33. What effect has oil on the valve?

34. What advantages other than good appearance has a cover for an extra tire?

35. When a car is stored how should the tires be cared for?

36. What effect has light and heat on tires?

37. What effect does oil have on tires?

(For answers to questions on this page, see pp. 173–178.)

38. How should oil be removed from tires?

39. What causes a tire to wear flat on the tread?

40. What is the method of detaching a clincher tire?

41. How can the inner tube be removed from a tire?

42. How is the casing of a tire entirely removed from the rim?

43. How is a tire assembled on the rim?

44. What indicates the inner tube is not pinched?

45. What is the best method of putting in an inner tube while on the road?

46. How should a new valve-stem be inserted in an inner tube?

47. What precautions are necessary in patching an inner tube?

48. What are some of the quick detachable methods?

49. What are the advantages of an entirely detachable rim?

TROUBLES

1. Should a chain break, what is the remedy?

2. Should a chain break on a double-chain drive, how could the car be driven with one chain?

3. Should a wheel break, how could it be repaired temporarily?

(For answers to questions on this page, see pp. 179–181.)

4. Should a drive-shaft break, how could it be repaired?

5. Should a spring break, how could the car be gotten home?

6. Should a fan-belt break, what would be the effect on the engine?

7 Should a fan break, how should it be repaired?

8. Should the pump break, would the water circulate?

9. Should a spark-plug break and none could be obtained, what precaution should be taken while operating the remaining cylinders?

10. Should a valve on a multicylinder motor break, how could the motor be operated with the remaining cylinders?

11. Why should a spark-plug not be screwed in too tight?

12. What are some of the troubles of a spark-plug?

13. How can you determine when the spark-plug causes missed explosions?

14. Should the motor stop on a steep hill, is there cause for alarm?

15. Should the first speed-gear strip, what should be done?

16. Should a car start down a hill backwards and the brakes do not hold, what should be done?

(For answers to questions on this page, see pp. 182–185.)

17. Should the vibrator refuse to work, where is the trouble?

18. Should the vibrator stick, what is the probable cause?

19. Should one cylinder of four stop firing, how should the trouble be located?

20. Should the carburetor spring a leak, how could it be repaired?

21. Should the gasoline pipe leak, what would temporarily repair it?

22. Should the gasoline-pipe cock leak, what would temporarily repair it?

23. Should the radiator leak badly, what would temporarily repair it?

24. Should the pump leak badly, how could it be packed?

25. Should the carburetor cough, what does it indicate?

26. Should the carburetor flood, where is the cause?

27. Should the carburetor float leak, how can it be found?

28. Should a knock be heard upon opening the throttle, what is the probable cause?

29. Should a knock be heard after traveling ten miles, what is the cause?

30. Should the engine lose power, where should it be looked for?

31. Should the motor skip on high speed, what is the cause?

(For answers to questions on this page, see pp. 185–187.)

32. Should the motor skip on low speed, what is the cause?

33. Should the motor slow down when the throttle is opened, what is the cause?

34. Should the car travel along at a moderate speed and when the throttle is opened and more speed attained the carburetor should cough, what is the cause?

35. Should the auxiliary air-valve on a carburetor stick and remain open, what effect would it have upon attempting to start the motor?

36. Should the motor fail to start upon cranking, what should be done?

37. Why should the motor not be turned over a half hour more or less if it fails to start?

38. Should one cylinder miss explosions every other time, where should the trouble be looked for?

39. Should the engine skip and pound when the throttle is opened, what is the probable cause?

40. Should a motor which had been skipping become overheated, what is the cause?

41. Should the starting-crank be lost, how could the motor be started?

42. Should the slow-speed or reverse transmission band of a planetary transmission start the car with a jump, how could it be remedied?

(For answers to questions on this page, see pp. 188–191.)

43. Should one rear wheel become loose, what would be the result?

44. Should one rear wheel be mired, how could the car be assisted?

45. Should a storage-battery lose its current quickly, what would be a probable cause?

46. Should a storage-battery after being charged give a weak current, what would be the cause?

47. Should a storage-battery case become cracked or broken from a fall, how could it be repaired?

48. Should a rubber hose kink at a short bend, what devise would prevent it?

49. Should a blow-out occur when no spare shoe is at hand, what could be done?

50. Should a puncture occur when no spare inner tube is at hand, what could be done?

51. Having two sets of dry cells, neither of which has enough strength to run the car, what is the remedy?

52. Should it be found that the dry cells were all run down, how could they be given new life?

53. Should sliding-gears make a loud noise when attempting to change gear, what is the cause?

54. Should the reverse gear become locked after backing, what is the cause?

55. Should the gears make a loud noise while attempting to reduce the gear, what is the cause?

(For answers to questions on this page, see pp. 191–194.)

56. Should the engine make a bumping noise and transmit a jerky motion to the car while traversing crowded streets, how can it be avoided?

57. Should a motor run for a minute and then stop, and after priming the carburetor and cranking again, it would run for a minute and then stop what is the probable cause?

ALCOHOL

1. From what materials may alcohol be produced?

2. About how much time is consumed in the production of alcohol?

3. Describe the process of extracting alcohol from potatoes.

4. How is the alcohol distilled?

5. Will alcohol absorb moisture from the air?

6. Upon what does the vaporization of alcohol for an internal combustion-engine depend?

7. What kind of a carburetor should be used for alcohol fuel?

8. What is the power of alcohol mixtures as compared with gasoline mixtures?

9. Why cannot wood alcohol be used for explosive motors?

10. Can a gasoline motor be operated with alcohol?

MISCELLANEOUS

(For answers to questions on this page, see pp. 195–198.)

1. How should a cape-cart top be secured when folded back?

2. What is necessary in regard to the position of the Prest-o-lite gas-tank on a car?

3. How can freezing of the gas-generator be prevented in winter?

4. How can the acetylene gas-burners be cleaned?

5. How can water be drawn from the horn?

6. How should the wicks of a kerosene lamp be adjusted to prevent oil from being drawn up and covering the outside when not in use?

7. What is the best method of cleaning oil and dirt from the engine?

8. What are some important points to be observed in grinding valves?

9. How should the front wheels be turned when a car is not in motion?

10. What is the best way to stop a car?

11. What is the effect of unequal pressure in the rear tires?

12. What will facilitate the inflation of tires?

13. What is meant by the horse-power rating of a car?

14. Of what value are horse-power ratings to the purchaser of a car?

ANSWERS

PARTS OF A MOTOR

(For questions to answers on this page, see p. 3.)

1. The cylinder (Fig. 1) is that part of the motor which is swept by the piston.

2. The piston is (Fig. 2) that part of the motor working within the cylinder upon which the expansive force of the gas acts.

3. The piston-pin—sometimes called the wrist-pin—is contained within the piston, and by which the piston and connecting-rod are attached.

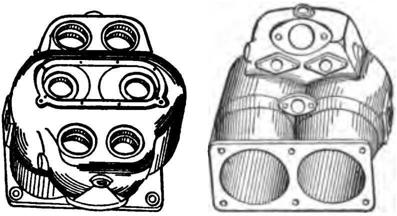


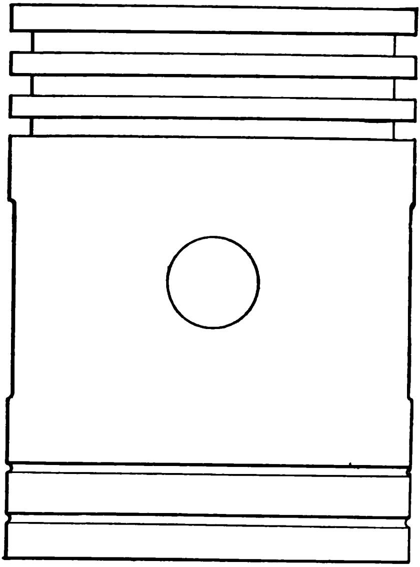
FIG. 1.

4. The connecting-rod (Fig. 3) sometimes called the piston-rod—connects the piston with the crank-shaft.

5. The crank-shaft (Fig. 4) is an irregular shaft which by means of the connecting-rod

(For questions to answers on this page, see p. 3.)

transforms the reciprocal motion of the piston into rotary motion.



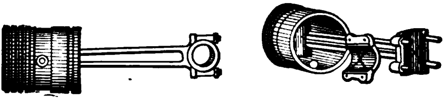


FIG. 2.

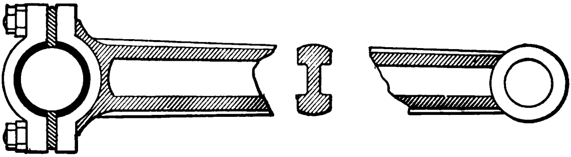


FIG. 3.

6. The crank-pin is that part of the crankshaft to which the connecting-rod is attached.

(For questions to answers on this page, see p. 3.)

7. The fly-wheel or balance-wheel (Fig. 5) is a heavy wheel fastened to the crank-shaft which by its momentum continues the rotation of the crank-shaft through the idle strokes of the piston.

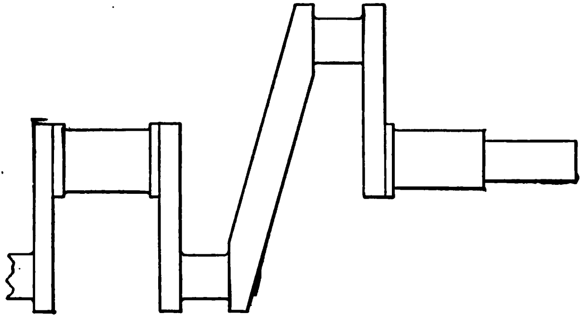


Fig. 4.

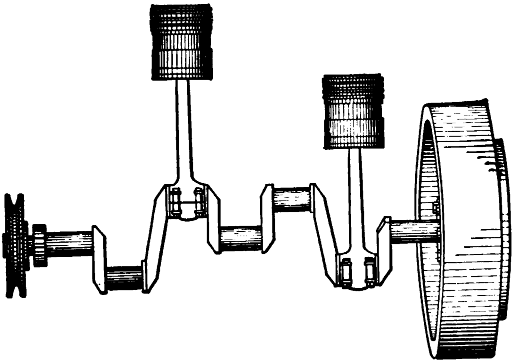


Fig. 5.

8. The combustion-chamber is that part of the cylinder not swept by the piston in which the gases are confined.

(For questions to answers on this page, see p. 3.)

9. The inlet-valve is that part of the motor closing the opening through which the gas is admitted.

10. The exhaust-valve is that part of the motor which closes the opening through which the gas is emitted.

11. The valve-stem is that part of the valve to which the head is attached and is operated upon by the cam.

12. The cam is a rotating part of the motor, irregularly shaped and rotating about a center different than its own, which actuates the valve mechanism.

13. The cam is placed on a shaft called the cam-shaft, or half-time shaft.

14. The cam-shaft, or half-time shaft, rotates at half the speed of the crank-shaft, and by means of the cam actuates the valve mechanism.

15. Two-to-one gears rotate the cam-shaft, the smaller being located on the crank-shaft, the other, twice as large, on the cam-shaft.

16. The push-rod bears upon the cam and is located directly in line with the valve-stem, which it actuates.

17. The crank-case is that part of the motor containing and enclosing the crank-shaft.

18. The spark-plug is an attachment through which the spark is introduced into the combustion-chamber.

(For questions to answers on this page, see p. 3.)

19. Packing-rings, or piston-rings (Fig. 6), are exspansible rings fitted to the piston, the object of which is to make a gas-tight joint between the cylinder-wall and piston.

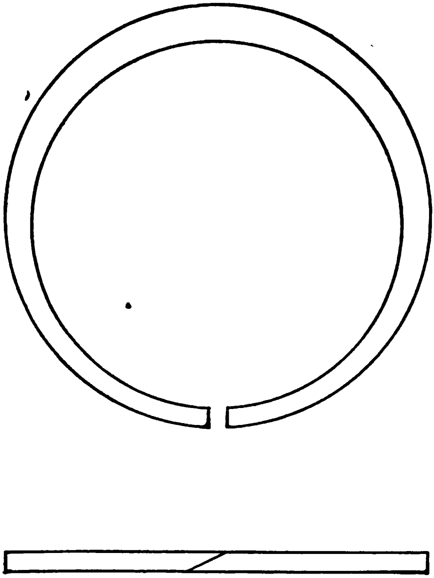


FIG. 6.

20. The governor is an attachment to automatically regulate the speed of the engine.

21. The timer, sometimes called the commutator, is an attachment by which the elec-

(For questions to answers on this page, see pp. 3–4.)

trical circuit is completed or interrupted at the proper time with relation to the position of the piston within the cylinder.

22. A gasket is a ring of compressible material, such as asbestos sheet, soft metal, or copper, inserted between two joints to make them gas- or liquid-tight.

23. The inlet-pipe is a pipe connecting the carburetor with the inlet-valve chamber.

24. The exhaust-pipe conducts away from the cylinder the exhaust gases.

25. The muffler is an attachment for silencing the noise of the exhaust gas.

26. A bushing is a ring of bearing metal placed between two rotating surfaces.

27. A multiple engine is one having more than one cylinder.

28. Piston-rings, or packing-rings (Fig. 6), are expansible rings fitted to the piston, the object of which is to make a gas-tight joint between the cylinder-wall and piston.

29. A compression relief-cock is placed midway of the piston-stroke in the cylinder. Its object is to relieve part of the compression to permit easy starting. It is sometimes placed in the combustion-chamber, and owing to its small opening all of the gases are prevented from escaping.

30. A bell-crank is a movable knee or elbow used to change the direction of pull or push of

(For questions to answers on this page, see p. 4.)

a rod, such as the spark-regulating device. The name bell-crank comes from the use of such devices to ring bells on steamboats, etc.

31. An eccentric is a circular disk or wheel rotating upon an axis different from its own center.

32. An auxiliary exhaust-valve is a valve placed at the bottom of the piston-stroke, connecting with the cylinder through a port to remove the hot exhaust gases quickly from the cylinder. Used only on Franklin air-cooled cars.

33. A spring-cotter is a piece of half-round wire folded together, forming an eye at one end, to be inserted in a hole in a bolt to prevent the nut from coming off and becoming lost should it loosen.

34. A lock-nut is an extra nut put on the same bolt with another nut and binding against it. A Columbia lock-nut is a patented article having a threaded center which is tapered and split. The tighter the nut is set up the tighter the tapered center grips the bolt threads.

35. A cap-screw differs from a bolt inasmuch as it is supposed to not go through the metal and has no nut upon it.

36. A stud-bolt is a double-threaded pin screwed firmly into a part. Another part can then be put over it and secured by a nut.

37. A set-screw differs from a cap-screw by

(For questions to answers on this page, see p. 4.)

being hardened and is intended to screw against a part to prevent it from moving. Set-screws have different points, designated as ball-, cup-, or round-pointed.

38. Liners, shims, or distance-washers are pieces of sheet-metal of varying thicknesses placed between a divided bushing to keep it a certain distance apart.

39. A key, or feather, is a rectangular piece of metal fitted into slots in a shaft and gear or wheel to hold them firmly to one another. Keys may either be straight or tapered or of the Woodruff patent, which is a semi-circular piece fitted into a circular cut in the shaft.

40. A check-valve is a valve placed in a pipe to prevent the return of gas or air pressure or the flow of liquid.

41. A relief-valve is a valve for relieving the pressure, sometimes placed in the crank-case to prevent pressure from forming by a leakage past the piston, which would force out the oil if splash lubrication was used. Sometimes used in the pressure line of the gasoline system to prevent excessive pressures in the gasoline-tank.

42. A spider is a hub having arms radiating from its center without a rim.

43. A clevis is a forked terminal of a rod.

44. A turnbuckle is a long nut having a right-hand thread in one end and a left-hand thread

(For questions to answers on this page, see p. 4.)

in the other, and draws the rods in each end nearer together.

45. A union is a fitting by means of which two pieces of pipe can be joined together and be readily taken apart without unscrewing the pipe.

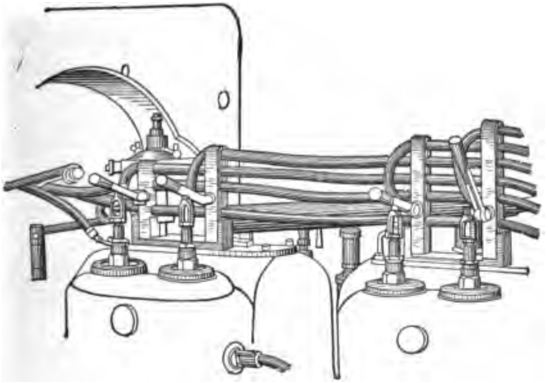


Fig. 7.—Wiring and switches of a four-cylinder motor.

46. A stuffing-nut is a nut which squeezes packing tightly around a pipe to prevent a leak.

47. A diaphragm is a flexible partition capable of being moved by pressure on one side, which motion is transferred mechanically by pressing against a piston on the other side.

48. A walking-beam is a part of the valve actuating mechanism placed on top of the

(For questions to answers on this page, see pp. 4–5.)

cylinder and transfers the upward motion of the push-rod into the downward motion of the valve-stem.

49. An apron, or under-cover, is a canvas, enamel cloth, or metal cover for the under side of the mechanism to keep it free from dirt.

50. A sprocket is the term used for a chain-wheel.

51. A jack-shaft is the shaft carrying the differential and driving sprockets on a double-chain driven car.

52. A solid rear axle is one used with double-chain drive.

53. A divided rear axle is the ordinary type used with the single-chain drive.

54. A floating type (Fig. 8) of rear axle is so called because the rear axle floats in the axle-casing, and the weight of the machine is supported by the axle-casing upon which the wheels revolve.

55. A transmission brake is a brake placed either on the jack-shaft on a double-chain driven car or immediately behind the transmission on a shaft-driven car, and on a drum attached to the driving-sprocket on a single-chain driven planetary transmission car.

56. A brake-shoe is a flexible part of the brake, sometimes called the brake-band.

57. A brake-drum is that part of the brake upon which the brake-shoe binds.

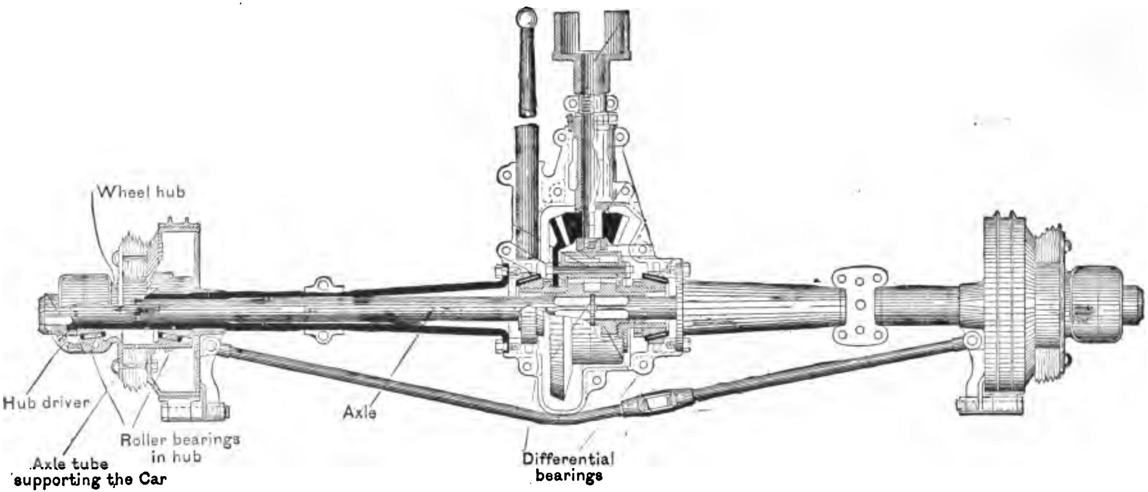

Wheel hub
Hub driver
Axle tube supporting the Car
Roller bearings in hub
Axle
Differential bearings

FIG. 8.

(For questions to answers on this page, see p. 5.)

58. The male member of a clutch, which is cone-shaped in the cone clutch, is usually faced with leather where it makes frictional contact with the female part, which is usually a part of the fly-wheel.

59. An expanding clutch consists usually of a flexible band capable of being expanded against the inner periphery of the fly-wheel, usually faced with leather.

60. A multiple-disk clutch is one having a number of metal disks alternately attached to the shaft and the fly-wheel, usually running in a bath of oil.

61. A contractional clutch is one whose flexible band grips a cylindrical projection upon the fly-wheel by being contracted.

62. An idler gear, or intermediate gear, is a gear running between two other gears to increase the distance between their centers or change their direction of rotation.

63. A silent gear is one composed of rawhide or fiber.

64. A rack-gear is a straight piece of metal having teeth upon it.

65. A worm-gear is a gear having teeth cut in a diagonal direction across its face.

66. A worm has teeth upon it like a screw.

67. A pinion-gear is the smaller of two gears running together.

(For questions to answers on this page, see p. 5.)

68. A spur-gear is the ordinary or straight-tooth gear.

69. Bevel-gears are two gears of different size running together having bevel faces and radial teeth.

70. Mitre gears are two gears of the same size having bevel faces and radial teeth.

71. A thrust-bearing is a bearing devised to prevent end motion of a shaft.

72. Hess-Bright bearings are non-adjustable annular ball bearings. The balls are kept apart by coiled springs. In order to assemble this bearing the balls are all put in at one side, then separated by placing the springs between them.

73. A cylinder jacket is a space around the outside of the cylinder which is filled with cooling-water.

74. A drain-cock is placed at the lowest point in the circulating system, and under the crank-case, to drain the contents.

75. A stand-pipe is usually a continuation of the drain-cock projecting inside the crank-case in order to maintain a certain height of oil therein.

76. A compression grease-cup is a cup holding grease that can be compressed either by a spring or by screwing down by hand the plunger which rests on top of the grease.

TWO-CYCLE MOTORS

(For questions to answers on this page, see p. 6.)

1. Two systems of two-cycle motors are used for automobiles, the two-port and the three-port.

2. A two-port two-cycle gas-engine (Fig. 9) has two ports in the cylinder and an inlet-valve into the crank-chamber or compression-chamber through which the gas is admitted.

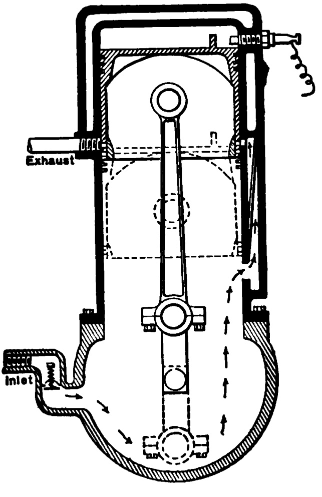


FIG. 9.—Two-port type of two-cycle motor.

3. A three-port two-cycle engine (Fig. 10) has two ports in the cylinder above the piston, and another port in the cylinder below the piston,

(For questions to answers on this page, see p. 6.)

which is uncovered only on the upward stroke of the piston and through which the gas enters the crank-chamber.

4. The operation of a two-cycle motor is as follows: Starting with the piston at its upward or inward position, a charge of gas is admitted to the crank-case. On the downward or outward stroke of the piston the charge in the crank-case is compressed. When the piston nears the end of its outward stroke it uncovers a port in the cylinder wall admitting the compressed charge from the crank-case through a passage-

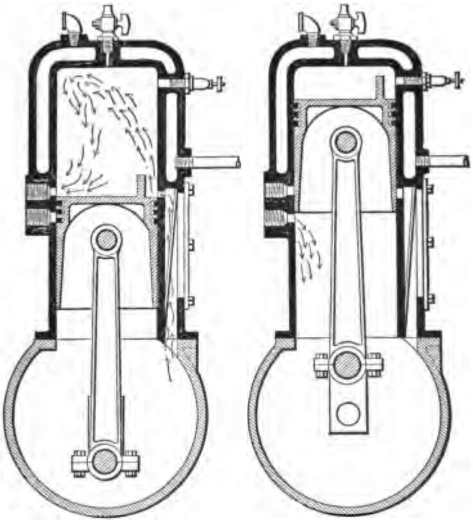


Fig. 10.—Three-port type of two-cycle motor.

(For questions to answers on this page, see p. 6.)

way into the cylinder. The upward movement of the piston closes the inlet-port and the charge is compressed in the cylinder by the upward movement of the piston. Upon reaching the inward position the charge is ignited and the expansion of the gas forces the piston out. Just before the inlet-port is uncovered again, a port on the side of the cylinder opposite to the inlet-port, called the exhaust-port, is uncovered and the gas through its own expansion makes its escape. Each downward or outward movement of the piston compresses a charge in the crank-case which has been drawn in by the previous upward or inward movement of the piston.

5. A projection called a baffle-plate is cast upon the piston (Fig. 11), situated near the inlet-port. Its object is to deflect the incoming gas upward, thus preventing it from rushing across the piston and passing out of the exhaust-port.

6. The passage-way from the crank-chamber to the cylinder through which the gas passes is called a by-pass.

7. A fine-mesh screen placed in the by-pass by quickly conducting away the heat prevents the charge in the crank-chamber from being ignited, thus preventing crank-case explosions.

8. About 15 pounds compression is secured in the crank-case with a full charge.

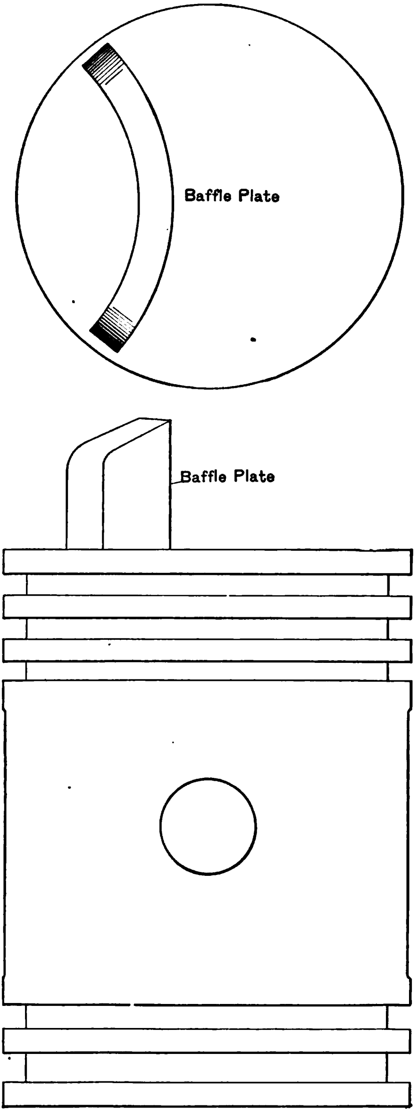


Fig. 11.—Two-cycle motor piston.

(For questions to answers on this page, see pp. 6–7.)

9. About 40 pounds compression is secured in the cylinder with a full charge.

10. The cause of missing explosions when the engine is throttled is due to the small amount of mixture admitted to the crank-chamber, reducing the compression therein to such an extent that the gas is not forced into the cylinder.

11. The compression in the crank-case of a two-cycle motor is prevented from escaping through the crank-shaft bearings by keeping the bearings filled with a heavy grease or oil.

12. Too late ignition and a too slow burning mixture causes crank-case explosions.

13. A two-cycle motor will run in either direction because the action of admitting and exhausting the gases are relative in either direction.

14. Having the spark occur too early or an incandescent projection in the cylinder would cause a two-cycle motor to run backwards.

15. A two-cycle engine can be reversed by switching off the electric spark until the speed of the engine decreases, then advancing the spark and switching on the current again.

16. A two-cycle engine cannot be reversed by an inexperienced person with any certainty. It requires considerable judgment and experience to reverse two-cycle engines.

17. The timer is very often attached to the

(For questions to answers on this page, see p. 7.)

crank-shaft of a two-cycle motor. As the spark occurs every revolution there is no necessity for the half-time shaft used in four-cycle motors.

18. Each cylinder of a two-cycle motor receives one power impulse to every revolution of the crank-shaft.

FOUR-CYCLE MOTORS

1. The word cycle as applied to gas-engines means one half a revolution of the fly-wheel or one stroke of the piston either in or out of the cylinder.

2. Two revolutions of the crank-shaft or four strokes of the piston are necessary for one power impulse in a four-cycle motor.

3. The four actions of a motor are admission, compression, expansion, and exhaust.

4. The first action which takes place in a four-cycle motor is the admission of the mixture of gasoline and air.

5. The gas is admitted to the cylinder through the inlet-valve, being drawn in through the inlet-pipe by the suction of the piston as it goes out of the cylinder.

6. After the mixture has been admitted to the cylinder the piston is forced in and the gas is compressed in the combustion-chamber.

(For questions to answers on this page, see pp. 7–8.)

7. After compression has taken place the spark occurs, igniting the mixture.

8. Having ignited the mixture the piston is forced out of the cylinder by the force of the expanding gas, which is due to rapid combustion.

9. As the piston nears the outward end of its stroke, the exhaust-valve is opened and the piston by its inward movement forces out the burned gas.

10. The ignition of the gas should take place at such a time that the force of the expanding gas shall be exerted upon the piston just as it starts on its outward travel.

11. The gas should be admitted to the cylinder by the opening of the inlet-valve just as the piston starts on its outward stroke, that is, the next outward stroke to the expansion stroke.

12. The exhaust-valve should open sufficiently early in the expansion stroke to permit the gases to pass out through the valve by their own expansion, thus relieving the piston of a great deal of pressure on its exhaust stroke.

13. The average number of pounds compression in a gas-engine cylinder is 65 pounds per square inch.

14. The direction of rotation cannot be changed in a four-cycle engine as usually made, except by changing the operation of the valves, because the exhaust-valve is opened on the

downward stroke, when the direction is reversed and the burned gas would be drawn back from the muffler.

VALVES

1. Inlet-valves are of two kinds, automatic and mechanical.

2. An automatic valve (Fig. 12) is opened by the suction of the piston, or, more correctly, because of the difference in pressure between the pressure within the cylinder and the atmospheric pressure without. It is closed by the action of its spring.

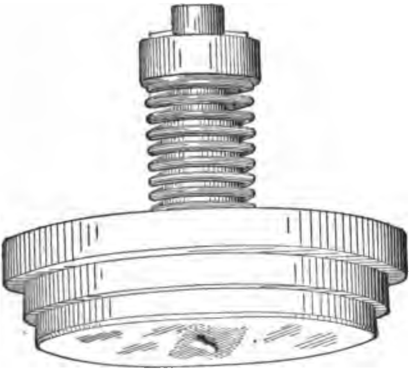


FIG. 12.

3. Increasing the tension of the spring on an

(For questions to answers on this page, see pp. 8–9.)

automatic inlet-valve reduces the amount of charge admitted to the cylinder.

4. An automatic valve cannot be used for the exhaust because it must open against the pressure of the gas.

5. It is not necessary for multiple engines to have mechanical inlet-valves, although the present tendency of construction is in that direction.

6. A mechanical valve is operated by a rotating cam.

7. There are two revolutions of the crank-shaft to one of the cam of a four-cycle motor.

8. An automatic valve does not always seat; it is liable to flutter on its seat. If the spring is of sufficient strength to close the valve it decreases the amount of gas admitted to the cylinder. Its opening is restricted and it cannot be timed.

9. A mechanical valve is positive in its action, always opening and closing at the proper time; it never sticks on its seat; it can be timed with relation to the position of the piston; it admits of a heavier closing spring, and the valve can be heavier and more substantial.

10. The inlet-valve should start to open as the piston starts on its downward or outward stroke.

11. The inlet-valve should close when the pressure of gas within the cylinder is equal to

(For questions to answers on this page, see p. 9.)

the atmospheric pressure, or as nearly as possible. On different makes of engines this position varies, but generally it is from 25° to 45° (measured on the fly-wheel) on the compression stroke.

12. The exhaust-valve should open a sufficient time before the piston has completed its working-stroke to relieve the pressure upon the piston as it starts on its exhaust stroke. This position varies with different makes, but generally it is from 3° to 10° (measured on the fly-wheel) before the cranks reach outward center on the expansion stroke.

13. The exhaust-valve should close at the completion of the exhaust stroke of the piston, or, in other words, when all of the burned gases that is possible have been exhausted, which is just as the piston starts on the admission stroke.

14. In the absence of specific instructions from the manufacturer, the time of closing of the exhaust-valve is just as the piston starts on the admission stroke, and the inlet-valve should open immediately after the exhaust has closed. The opening of the exhaust and the closing of the inlet-valves will be [illegible] the wear has not occurred, when the closing of the exhaust and the opening of the inlet-valves are correct.

15. The exhaust-valve is opened by the action of the cam raising it from its seat.

(For questions to answers on this page, see p. 9.)

16. The exhaust-valve is closed by the tension of its spring.

17. Should the exhaust-valve not open at the proper time, the pressure on the piston cannot be relieved, thus to a degree preventing it from returning on the inward stroke, resulting in a loss of power.

18. If the exhaust-valve failed to close, the exhaust gas would be drawn back from the muffler by the suction of the piston and no explosion would result, or if it only partly closed, a weak explosion would result.

19. Valves opening early and closing late indicate too long a valve-stem or push-rod. Push-rods are very often adjustable.

20. Valves opening late and closing early may be caused by too short a valve-stem, a loose cam on the cam-shaft, or a loose gear on the cam-shaft or crank-shaft, or a worn cam or gear.

21. Valves opening early and closing early indicate that the cam-shaft gears are not properly meshed, as does also opening late and closing late.

22. A cam loose on its shaft would have the effect of opening late and closing the valve early, because in opening the looseness will be taken up, thus delaying the opening. Upon closing, as the cam passed over its center, the valve-spring tension would take up the looseness in the other direction and the valve would

(For questions to answers on this page, see pp. 9, 10.)

close early, thus shortening the duration of opening.

23. In seating valves when the engine is cold an allowance should be made for the elongation of the valve-stem, due to heat expansion, or the valve will not seat when the engine is hot. Usually a space wide enough to admit the thickness of a postal-card is sufficient.

24. A hard piece of emery will form a groove in the valve and its seat if the valve is turned round and round and considerable pressure is used in grinding.

25. The proper way to grind a valve is to remove the spring, apply a paste of fine emery or quartz (which is better mixed with oil) to the valve, then with a screw-driver and light pressure turn the valve quarter-way around and back a number of times, then raising the valve from its seat, turn partly and repeat the operation.

26. It is necessary to grind valves—exhaust-valves more frequently—because the heat acts upon the metal, pitting it, and the hammering of the valve on its seat wears it unevenly. The frequency of valve grinding depends upon the material of which the valve is made, its design, and largely to the conditions under which the engine operates, which is under the control of the chauffeur.

27. Too much lubrication in the cylinder,

(For questions to answers on this page, see p. 10.)

excessive heat, or a too tight-fitting valve-stem will cause the exhaust-valve to stick.

28. Should the exhaust-valve stick it would stay open, causing the motor to fail to receive a new charge of gas.

29. Should the exhaust-valve stick it would be necessary to remove it to remedy the trouble.

30. A weak exhaust-valve spring would permit the exhaust gases to be drawn in on the suction stroke when the throttle is closed, thus diluting the charge and reducing the power, or the valve might not seat quickly enough to retain the gas and at high speeds would rebound from its seat.

31. A pitted valve would permit the compressed gas to escape.

32. If in grinding a valve, grooves have been cut in the valve and its seat, it will not be tight, because the valve-stem being comparatively loose or slightly loose in its guide, the valve would not seat exactly in the grooves each time it closed, and the apex of the ridges on both the valve and its seat would be bent over, thus preventing the valve from seating correctly.

33. Filling the valve with gasoline is of no value. Even if gasoline will run out of a very small opening, the valve, having ridges in its seat, would hold the gasoline, but as the backs of the ridges become bent over it would not hold even water.

34. If upon examination the valve and its

(For questions to answers on this page, see pp. 10, 11.)

seat shows a fine dull finish all around without ridges it is seated properly.

35. When valves have been reground several times a shoulder is formed on the head, which owing to the looseness of the stem in its guide would strike on the edge of the seat. In some cases it will remain there and the valve will not close. It is better to file off the shoulder before grinding.

36. When the valve-stem is hot, if the valve is held up on one edge by a broken piece of a spark-plug or other foreign object getting into the cylinder, it is very liable to bend the stem to such an extent that it will necessitate its removal to be straightened.

37. When the compression is poor, or when the motor skips with closed throttle, it is probable that the exhaust-valves need grinding.

38. A valve-stem can be lengthened by drilling and tapping a hole in its end, then braze in a filister-head screw and file off to the required length.

COOLING

1. The usual acceptance of the reason for cooling a gasolene-motor by the average automobilist is that the motor should be kept

(For questions to answers on this page, see p. 11.)

as cool as possible. This idea is erroneous because the hotter the motor is (within certain limits) the greater will be its power.

2. The gasoline motor depends upon heat for its power, and will not develop its full power until the cylinder walls become heated and the units of heat which the water or air will absorb has been reduced to the minimum. In other words, the nearer to the boiling-point, which is 212° F., the water becomes, the less power it will take away from the motor. Skillful operators engaged in demonstrating the ability of cars realize this, and when showing a cold motor to a prospective customer give the motor lots of gas and a late spark to heat it up before attempting a climb.

3. The object of cooling a motor is to prevent the cylinder walls from expanding unequally, thus allowing the force of expansion of the gas to escape past the piston; to prevent the lubricating-oil from burning; to permit a full charge to be drawn in and compressed before igniting.

4. There are two systems of cooling automobile motors in general use: one by water, the other by air.

5. There are two methods of cooling by water (Fig. 13). One, the thermo-siphon system, in which the water is circulated through the water-jackets surrounding the cylinders by utilizing the principle that water as it be-

(For questions to answers on this page, see p. 11.)

comes heated expands, and colder water, being heavier, takes its place. This method depends for its successful operation upon the arrangement of the tank and piping, in which the tank containing the cold water must be not lower than the lower portion of the cylinder water-jackets where the water is heated. This system is used in heating dwellings with hot water. The other method depends upon the action of a pump which is connected into the lowest point of the circulating system, receives the cool water from the radiator and forces it through the cylinder jackets. The pump is

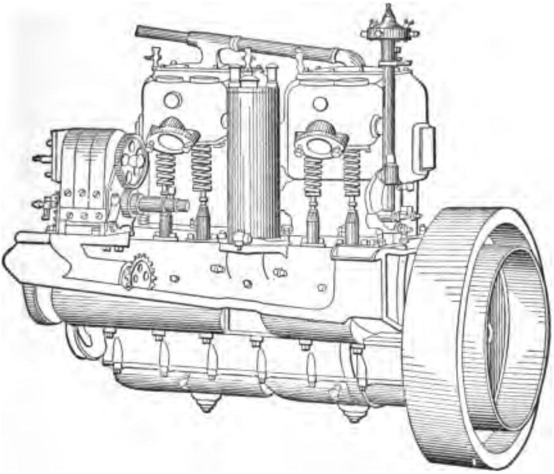


Fig. 13.—A water-cooled multiple-cylinder engine.

(For questions to answers on this page, see p. 11.)

connected into the system at the lowest point to allow the water from the radiator to flow to it by gravity.

6. There are several methods of cooling the cylinders by air, some of which are: Studding the cylinder with pins which have been threaded to increase their surfaces; casting the cylinder with ribs or flanges on them (frontispiece); inserting in grooves comb-shaped pieces of flat metal; and jacketing the cylinder through which a strong current of air is forced by a blower.

7. A fan driven by a belt or gear from some part of the motor is a part of the equipment of many water-cooled as well as air-cooled cars. In the water-cooled cars the fan draws a current of air through the radiator, which cools the water while going at slow speed or when the car is stopped and the engine running. In the air-cooled cars the fan increases the circulation of air around the cylinders.

8. The fan is of no benefit when traveling at high speed over the road on either water- or air-cooled cars, and should the belt break, the fan would be propelled by the air coming through the front of the hood faster than the belt would drive it.

9. In filling the cooling system with water, care must be taken that there are no air-pockets in the system. The best way to prevent the

(For questions to answers on this page, see p. 11.)

forming of air-pockets is to fill the system from the lowest point.

10. Should an air-pocket be formed it would cause no trouble until it reached the pump, where it would remain. Owing to the fact that the pump is not built to pump air it cannot force it against the pressure of the water above it and the air remains in the pump.

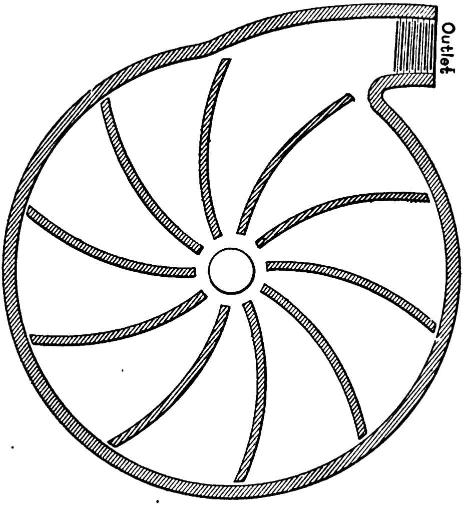


FIG. 14.—Centrifugal pump.

11. An air-pocket is indicated by the water in the cylinder jacket becoming hot while the water in the radiator is cold. To release an air-pocket, the drain-cock under the pump should be opened and a little water drawn out. If no

(For questions to answers on this page, see p. 11.)

drain-cock is provided, loosen the casing of the pump for a moment.

12. Should the gear which drives the pump become loose or the pump refuse to work, the symptoms would be identical with those caused by an air-pocket, and should it be found impracticable to repair on the road, the inside should be taken out, or the pipes leading to and from the pump should be connected together, thus permitting a slight circulation without the pump, as in the thermo-siphon system.

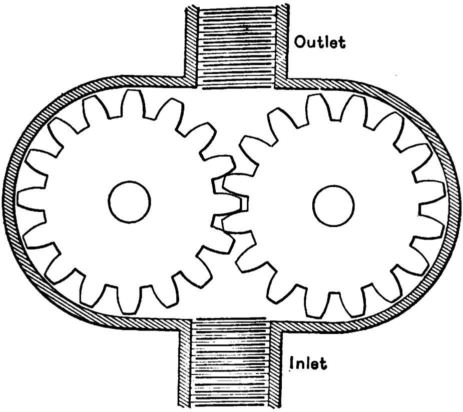


Fig. 15.—Gear pump.

13. There are three styles of pumps in general use—centrifugal, gear, and eccentric. The centrifugal pump (Fig. 14) is composed of a flat disk having ribs or vanes radiating from the center,

enclosed in a casing, which it nearly fills. The water entering at the center is forced to the outside by the centrifugal action of the rapidly

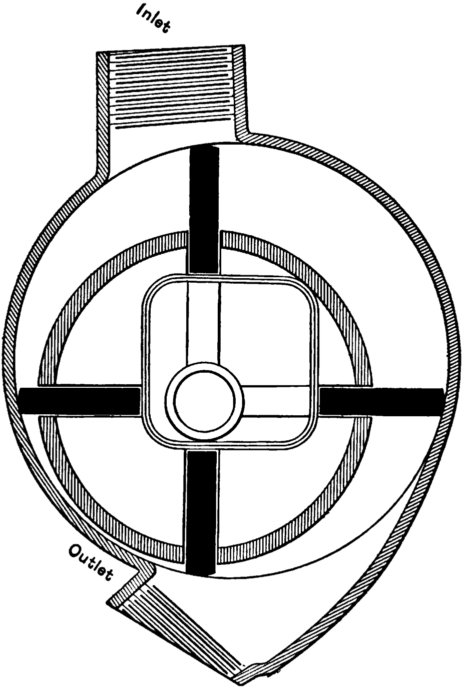


FIG. 16.—Eccentric pump.

revolving disk, from whence it goes to the cylinder jackets. The gear pump (Fig. 15) is a casing enclosing two gears running with their teeth together. The water entering at one side enters the teeth which are not in mesh, and is carried

(For questions to answers on this page, see p. 11, 12.)

around by them to the other side; being prevented from returning between the gears, it is forced to the cylinder jackets. The eccentric pump (Fig. 16) is composed of a circular casing or drum having a smaller drum within journaled out of the center of the casing, one side of which it nearly touches. Contained within this smaller drum are four arms or paddles that spring out and make contact with the sides of the casing as the drum revolves. Water entering the side of the casing farthest from the drum fills the opening between the paddles, and is forced into the smaller space containing the outlet as the drum revolves.

14. Some of the advantages of the air-cooled car are: light weight, no water to leak or carry, absence of plumbing, and nothing to freeze in winter.

15. To prevent the cooling system of a water-cooled car from freezing in winter, fill the system with a 25% solution of alcohol. This will stand a temperature of 5 degrees above zero without freezing. For lower temperatures add more alcohol.

16. It is very good practice to drain the water from the cooling system once each month to remove any corrosion, rust, etc. Start the motor and open the drain-cocks. Fill the radiator as the water runs out to avoid air-pockets.

CARBURETORS.

(For questions to answers on this page, see p. 12.)

1. Gasoline is composed of carbon and hydrogen chemically combined in certain proportions.

2. The function of a carburetor is to combine with air the gasoline in proper proportions, supplying a highly expolsive mixture or gas to the engine.

3. The proportion of gasoline mixed with the air varies according to the conditions of the atmosphere and the quality of gasoline. Roughly, ten to sixteen parts of air to one of gasoline is the proper mixture.

4. The air is necessary to furnish oxygen to combine with the hydrogen in order to make the combustion complete. Gasoline will not burn without air. Remember this when gasoline catches fire: exclude the air if possible and the fire will go out.

5. There are two systems of carburetors in general use: the float-feed and mixing-valve (description later). Each works on a different method, but the results are approximately the same.

6. In the float-feed carburetor (Fig. 17) the gasoline from the tank enters a separate chamber called the float-chamber, so-called because it contains a float.

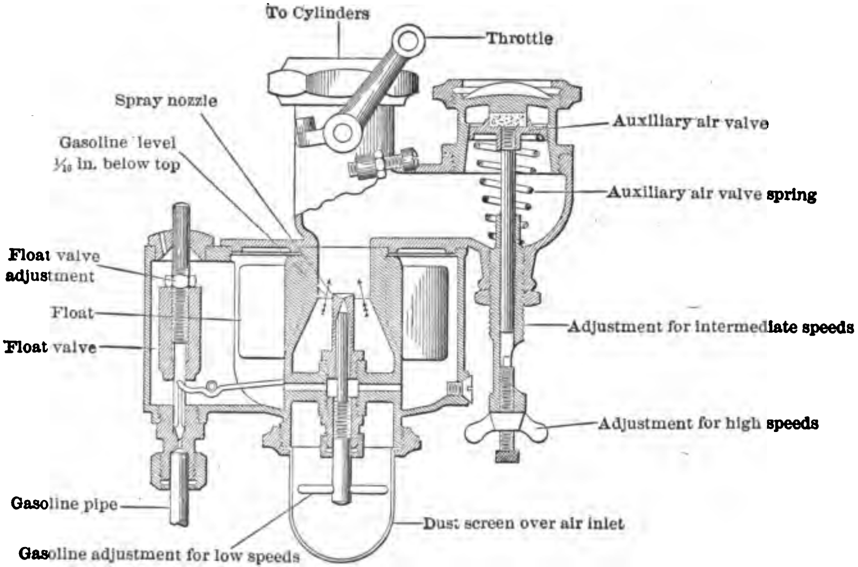

To Cylinders
Throttle
Spray nozzle
Gasoline level $\frac{1}{16}$ in. below top
Auxiliary air valve
Auxiliary air valve spring
Float valve adjustment
Float
Float valve
Adjustment for intermediate speeds
Adjustment for high speeds
Gasoline pipe
Dust screen over air inlet
Gasoline adjustment for low speeds

FIG. 17.—Float-feed carburetor

(For questions to answers on this page, see pp. 12, 13.)

7. Floats in general use are of two kinds.

8. Cork and air-tight metal cylinders are usually employed, although any buoyant material can be used.

9. If the carburetor float has been damaged, a piece of wood will answer temporarily for a float, but in time will absorb gasoline and become less buoyant.

10. The height of gasoline within the float-chamber is regulated by the needle or ball-valve attachment to the float, which is capable of adjustment.

11. As the gasoline enters the float-chamber the float rises and when the proper height is reached cuts off the supply by closing the valve to which it is attached.

12. By the law of liquids the gasoline finds its level in a stand-pipe or spray-nozzle, to which it passes by way of a pipe or passage-way at or near the bottom of the float-chamber.

13. The spray-nozzle is located within a cylindrical-shaped part of the carburetor called the mixing-chamber, through which the air is drawn by the suction of the piston.

14. The correct height to which the gasoline should rise in the spray-nozzle is usually one sixteenth of an inch below the top. In this position it can be drawn by the suction of the piston at the same time that air is drawn through the mixing-chamber.

(For answers to questions on this page, see p. 13.)

15. The suction of the piston draws the gasoline from the spray-nozzle in the form of a spray which readily mixes with the air and forms a highly explosive mixture.

16. By the quality of the mixture is meant the percentage of gasoline of which the gas is composed.

17. The quality of the gas depends upon two things, viz., the size of opening in the spray-nozzle through which the gasoline is drawn or the velocity with which the air passes the spray-nozzle on its way to the cylinder.

18. In some styles of carburetors the opening in the spray-nozzle is controlled by a needle-valve which is capable of adjustment (Fig. 17), In this style the opening through which the air passes is fixed and the velocity varies only with the speed of the engine.

19. In another style of carburetor (Fig. 18) the opening through which the air is drawn is provided with a shutter by which the opening can be increased or decreased, resulting in an increased or decreased suction on the spray-nozzle, consequently a greater or less amount of gasoline in the mixture.

20. On some cars a lever from the air-shutter is placed on the dashboard and can be adjusted while running if desired.

21. The speed of the piston makes a great difference to the suction, and as a mixture of

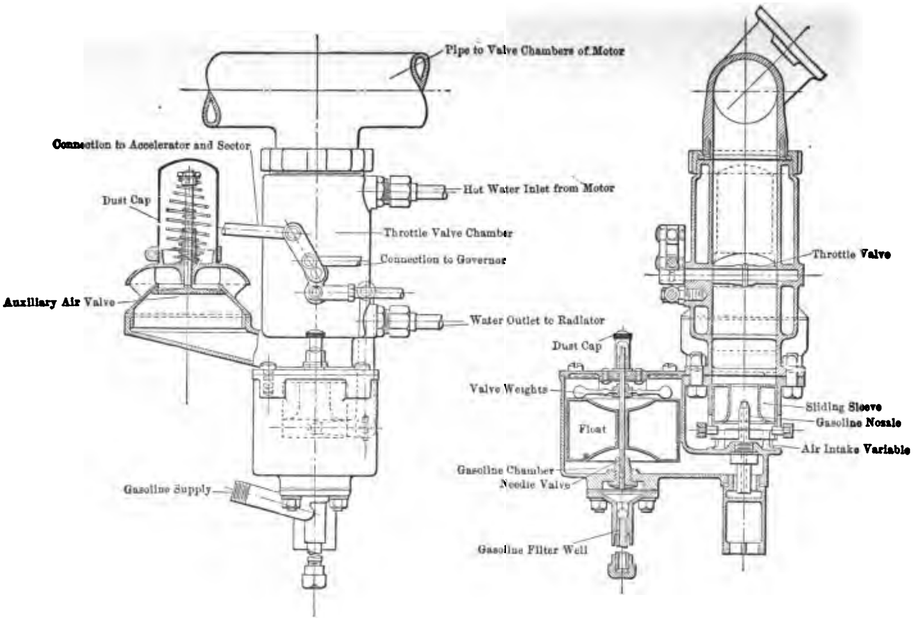


FIG. 18.—Two views of a float-feed carburetor.

(For questions to answers on this page, see p. 13.)

uniform quality must be maintained under varying suctions and velocities of air, some means of relieving the suction upon the spray-plug must be provided for high engine speeds.

22. The auxiliary air-valve is provided to supply an increased volume of air, which results in keeping the mixture uniform in quality even though there is more gasoline drawn from the spray-nozzle.

23. The auxiliary air-valve is held upon its seat by a spring whose tension is capable of adjustment and should not open at slow-piston speeds.

24. As the engine speeds up and the piston suction increases, the spring tension is overcome and air is drawn through the auxiliary valve to mix with the mixture containing a large percentage of gasoline, which has been drawn from the spray-nozzle by the suction necessary to overcome the spring tension of the auxiliary valve.

25. The auxiliary air-valve is used at intermediate and high-engine speeds only.

26. Two adjustments are provided on some carburetors for the auxiliary air-valve (Fig. 17), one of which limits the opening of the valve which is for the highest speed of the engine and the other adjusts the spring tension for intermediate speeds.

27. The height at which the gasoline stands below the top of the spray-nozzle has con-

(For questions to answers on this page, see pp. 13, 14.)

siderable effect upon the adjustment of a carburetor. If the float-valve does not shut off the supply, the gasoline overflows and the mixture is too rich. If the float-valve cuts off the supply before the proper level is reached, the suction necessary to draw gasoline from the spray-plug will be greater.

28. When the level is too low, the suction required at high speeds will be so great that when the gasoline is drawn its form will be a stream instead of a spray and the inertia of the gasoline will cause the flow to continue after the suction is relieved, resulting in too rich a mixture for the next charge.

29. Priming the carburetor is accomplished by depressing the float and permitting the gasoline to overflow the spray-plug.

30. A restricted passage from the float-chamber to the spray-plug, due to an accumulation of dirt, lint, etc., will cause the mixture to become too light at high-engine speeds, although the mixture for slow speeds is good.

31. Too rich a mixture is indicated by black smoke issuing from the muffler, lack of life to the explosion, strong odor from exhaust, poor power, and a pasty soot on spark-plugs.

32. Too weak a mixture is indicated by missed explosions, explosions in the muffler, explosions through the carburetor (called coughing at the carburetor), and poor power.

(For questions to answers on this page, see p. 14.)

33. In adjusting a carburetor, adjust until the mixture is too weak, then give it sufficient gasoline to get the power desired. Use as little gasoline as possible to obtain the desired results at any speed.

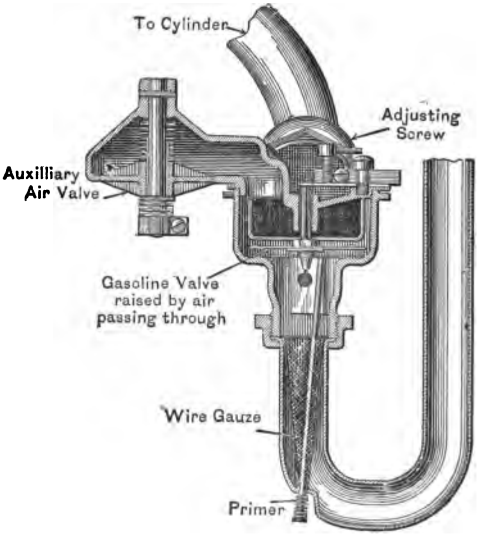


FIG. 19.—Mixing-valve carburetor.

34. A carburetor having no float-chamber or constant-level device (Fig. 19) is called a mixing-valve carburetor.

35. The mixing-valve carburetor having a valve which is opened by the passage of air through the chamber in which it is placed permits the gasoline to flow out of the valve

(For questions to answers on this page, see p. 14.)

and drip upon the walls and parts of the mixing-chamber.

36. The air passing through the mixing-chamber is impregnated with the gasoline through which it passes on its way to the cylinder.

37. In some styles of mixing-valves the opening through which the gasoline passes is controlled by a needle-valve. In other styles the limit of lift of the valve is controlled by an adjustment in order to regulate the quality of the mixture.

38. The mixing-valve style of carburetor must be primed before starting because the air in passing through the carburetor the first time comes in contact with no gasoline.

39. The method of priming a mixing-valve is by raising the valve off its seat, thus permitting the gasoline to flow.

40. The mixing-valve is not used extensively on automobiles because considerable difficulty is experienced in securing a perfect mixture at varying piston speeds.

41. By fitting a circular disk of thin metal having portions punched out to the valve, the air in raising it will whirl and dash the gasoline against the sides of the chamber, and by closing the valve quickly upon a seat that is covered with gasoline will form a spray which can be more readily taken up by the passing air.

(For questions to answers on this page, see pp. 14, 15.)

42. The majority of American automobiles use the gravity system for supplying the carburetor with gasoline from the tank, in which case the tank is placed higher than the carburetor.

43. In a number of cars the gasoline-tank is carried at the rear and lower than the carburetor, in which case the gasoline is raised by pressure.

44. Air-pressure from a pump connected to the engine; hand-pump pressure; or the pressure of the exhaust is used to raise the gasoline to a higher level.

45. By conducting the exhaust pressure to the gasoline-tank through a small pipe it is cooled and any glowing particles of carbon therein do not reach the tank until they are cool.

46. The exhaust pressure when used for a gasoline-tank deposits considerable carbon particles, oil, etc., therein, which are liable to clog the supply-pipe.

47. The number of pounds pressure per square inch required in a tank to raise the gasoline is not over 4 pounds, and in a great many cases 2 pounds is sufficient.

48. By providing a small auxiliary gasoline-tank higher than the carburetor the pressure in the main tank will be sufficient before the auxiliary tank is empty.

49. By straining gasoline through chamois

(For questions to answers on this page, see p. 15.)

skin, water and particles of dirt will be prevented from entering the tank. Using cloth or muslin is not good practice, because a lint will come from the cloth which will, if the practice is continued, obstruct the opening in the carburetor.

COILS

1. Spark-coils as used on automobiles are of two kinds, the plain spark-coil, which is used in the low-tension or make-and-break system of ignition, and the induction-coil or Ruhmkorff coil, which is used in the jump-spark or high-tension system.

2. Spark-coils as used in the low-tension or make-and-break system consist of an iron core and a simple winding of wire over it.

3. Induction or Ruhmkorff coils (Fig. 20) as used in the jump-spark or high-tension system are composed of a core over which is a winding of coarse wire called the primary winding, and over this is a winding of many turns of very fine wire called the secondary winding.

4. Induction-coils may be of two systems, vibrating and non-vibrating.

5. The primary winding is made of large or coarse wire to reduce the resistance to the flow of the current, and to carry a large current in

(For questions to answers on this page, see p. 15.)

order to produce a strong magnetic field. A current of electricity surrounds a wire and does not go through it as water does through a pipe, a large wire will conduct the current with less resistance than a small wire.

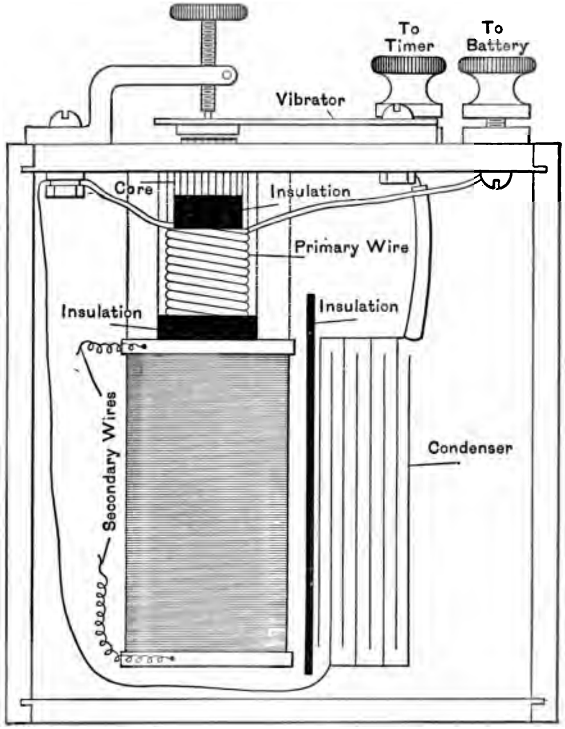


Fig. 20.—Jump-spark coil.

6. The secondary winding is composed of

(For questions to answers on this page, see pp. 15, 16.)

many turns of a very fine wire, and because of the high voltage generated the resistance of this wire is of little concern.

7. The cause of current in the secondary winding of an induction-coil is that the windings are within a magnetic field formed by the current flowing along the primary winding. The primary winding only is connected to the battery current. The secondary winding of an induction-coil is not connected to the primary winding, and the current in the secondary winding is caused wholly by induction.

8. Each wire of both primary and secondary coils are electrically insulated from, and do not touch, each other. The thorough insulation of the winding is important, and should the insulation be imperfect the strength of the coil would be reduced.

9. The core is composed of a bundle of soft-iron wires over which the primary wire is wound. The reason that a bundle of wires is used for the core instead of a solid rod is that the wire core can be more rapidly magnetized and demagnetized.

10. In all electrical currents flowing along coiled conductors a counter-current is created which opposes any rapid change in the current strength. This is called self-induction, and in the workings of a Ruhmkorff coil a condenser is provided to take care of the self-induced

(For questions to answers on this page, see p. 16.)

currents in order that the action of the coil may be more rapid.

11. The condenser is composed usually of a number of layers of tin-foil, separated by paraffin paper, each alternate layer connected at their ends. The condenser can be made from two sheets of tin-foil as well as from a number of layers, in which case connection is made to each strip at opposite ends. The operation of the condenser is like that of a Leyden jar, and it remains charged until discharged by contact or other methods.

12. The object of the condenser is to absorb the self-induced current of the primary winding and thus prevent it from opposing the rapid fall of the current.

13. In the operation of the induction-coil the battery current flows along the primary winding when the circuit is closed. This action forms a magnetic field about the primary coil in which the secondary wire is wound, producing therein a strong induced current. When the circuit is broken the current in the primary winding falls and another current is created in the secondary winding, which jumps across the gap at the spark-plug. In order to make the fall of the current in the primary winding rapid, the heavy self-induced current which would oppose the fall is absorbed by the condenser. The condenser gives up the current to the primary

(For questions to answers on this page, see p. 16.)

winding when the circuit is completed again, thus assisting the battery current.

14. The current strength in the secondary winding depends upon the rapidity with which the current in the primary winding falls. If a condenser was not used the gradual fall of the primary current would produce a feeble current in the secondary winding.

15. The voltage of the battery current at which spark coils usually found on the market will work best is not over 7½ volts.

16. The voltage of the primary current and of the primary winding of the coil is not greater than 7½ volts.

17. The voltage of the secondary current varies according to the method of manufacture and the number of turns of wire within the secondary coil, but is roughly stated at from 30,000 to 40,000 volts.

18. The amperage of the primary winding is less than 1 ampere, and many coils of reliable manufacture use less than ½ an ampere of current.

19. The amperage of the secondary current is reduced in direct proportion as the voltage of the secondary current is increased, and is approximately 1/60,000 part of an ampere.

20. The vibrator is a thin piece of spring steel having a soft-iron button or hammer attached to the free end, poised over the extension of

(For questions to answers on this page, see p. 16.)

the core. A platinum point on the vibrator makes contact with a platinum-tipped adjustable screw. The operation of the vibrator is that as the current flows along the primary winding the core is magnetized and attracts the iron button on the vibrator, separating the platinum points. Separation of the contacts causes a break in the circuit and the core loses its magnetism, releasing the spring, which falls back into contact with the screw, again completing the circuit. This action is repeated as long as the circuit remains closed at the timer. Each time that the circuit is broken a secondary spark jumps at the spark-plug. The advantages of the vibrator are: the circuit is rapidly broken, giving a number of sparks at the spark-plug during the time of contact at the timer; the battery-current consumption is lessened.

21. Excessive sparking at the vibrator-points denotes either a loose condenser connection; too much battery current; or the contact-points do not separate rapidly enough, due to improper spring tension; dirty or pitted vibrator-points.

22. The self-induced current by prolonging the flow of the primary current would cause a large spark at the vibrator-points were it not absorbed by the condenser.

23. It is impossible to adjust a coil advantageously to battery consumption and correct ignition by the sound of the vibrator.

(For questions to answers on this page, see p. 16.)

24. The method of connecting an ammeter in circuit to show the current consumption of the coil is to open the switch and make contact with the ammeter across the opening. The ammeter now serves as a switch and all the current consumed will pass through the ammeter, registering as it flows. With the motor running, the indicator of the ammeter will fluctuate and perhaps run from ¼ to 2 amperes. With the motor stopped and the vibrator continually buzzing, the coil should not consume more than 1 ampere.

25. To correctly adjust the vibrator, see that the contact-points are clean and have a flat surface, making the contact squarely. Adjust the tension of the spring so that the hammer is about $\frac{1}{16}$ of an inch from the top of the core. Screw down the adjustment until it just makes contact with the platinum point on the spring. Now set the vibrator in motion by completing the circuit through the ammeter. The coil should not use at this time more than one ampere. Start the motor and so adjust the contact screw that it will give the best results. After this is accomplished, again test the coil, and if it draws more than one ampere, decrease the tension of the vibrator-spring and adjust again. Continue until the coil gives good results, i.e., the motor runs at its best and the coil does not draw too much current. Increasing the tension

(For questions to answers on this page, see p. 16, 17.)

of the vibrator-spring increases the current consumption.

26. Causing the spark to jump the greatest distance possible imposes a very severe strain upon the insulation of the secondary winding.

27. Four coils are generally used on a four-cylinder car and this system has a number of advantages, such as in locating ignition troubles, the connections on the different coils can be changed. If the trouble follows the connections it is evident the coil is not at fault, but if the trouble remains at the same coil connected to a different cylinder, the coil is the place where the trouble will be found. The unit system of spark-coils greatly facilitates this operation and is being generally adopted by manufacturers.

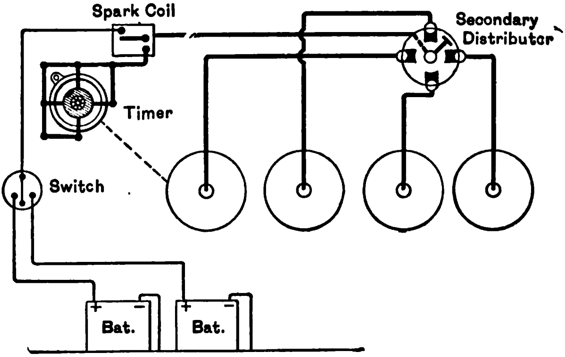


Fig. 21.—Diagram of the wiring of a four-cylinder motor using one spark-coil.

(For questions to answers on this page, see p. 17.)

28. By having a secondary distributor one coil can be used to ignite a four-cylinder motor (Fig. 21). This system has its advantages, some of which are synchronous ignition; it reduces the number of electrical connections, and has one coil only to adjust.

29. The vibrator is not a necessary part of the jump-spark system, but it is advantageous. If the vibrator refuses to work, the coil can be used without the vibrator by connecting the condenser across the point where the interruption of the circuit takes place, which would be at the timer.

TIMERS

1. The object of the timer is to close the electric circuit, thus producing the igniting spark within the cylinder at the proper time with relation to the position of the piston.

2. The different kinds of contacts employed are touch-contact or make-and-break, roller contact, sliding contact, and brush contact.

3. In the touch or make-and-break system of timers (Fig. 22) a flat spring bearing a platinum point is employed, which is forced into contact with a platinum-tipped adjustable screw by the action of a cam or roller.

(For questions to answers on this page, see p. 17.)

4. In the roller-contact system (Fig. 23) an arm attached to the cam-shaft carries at its free end a roller which, as the arm is carried around by the cam-shaft, makes contact with the segments of the commutator.

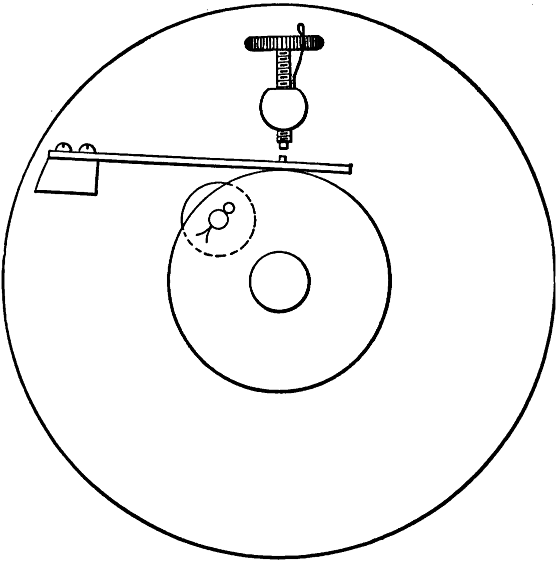


Fig. 22.—Touch-contact timer.

5. In the sliding-contact system (Fig. 24) a commutator containing hardened-steel contact points depress a hardened-steel spring actuated point on the rotor as it makes contact with them.

(For questions to answers on this page, see p. 17.)

6. In the brush system (Fig. 25) one or more brass brushes bear upon a commutator containing a metal segment which as it revolves makes contact with them.

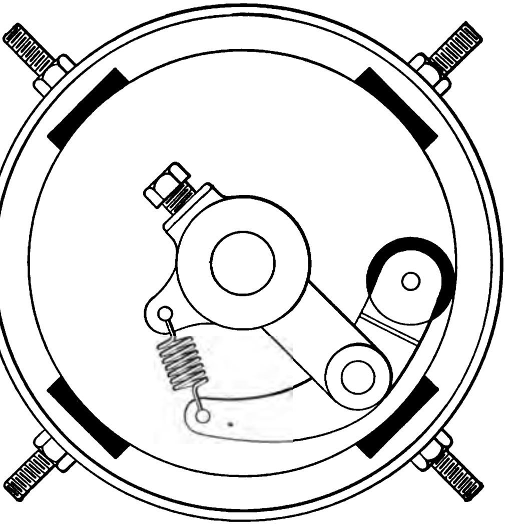


FIG. 23.—Roller-contact timer.

7. In igniting a multiple-cylinder motor satisfactory results are only obtained by synchronous timing, which is impossible with the timer having no adjustment for the separate contacts.

8. The commutator is that part of a timer which is made of insulating material having the contact pieces set into it. The material usually used for commutators is wood fibre, which

(For questions to answers on this page, see p. 17.)

wears better even than the hardened-steel contact pieces.

9. As the commutator is rapidly rotating, any uneveness in the surface upon which the brushes bear will cause them to jump, and before they rest again the contact piece has passed. The same thing occurs in the style of timer in which the commutator does not rotate, called the roller-contact system. The effect on the engine when the timer is worn is to cause missed explosions, which occur only at high speed.

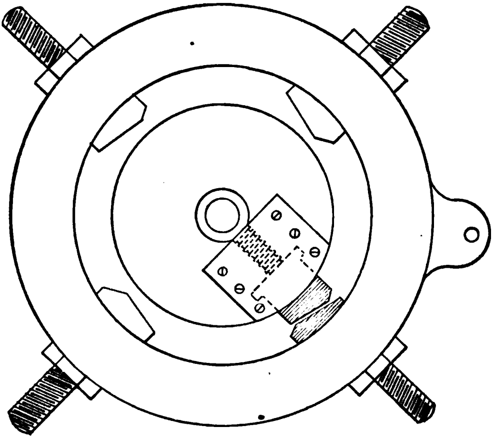


FIG. 24.—Sliding-contact timer.

10. Most all timers make a good contact even when filled with a lubricant, and to prevent

(For questions to answers on this page, see p. 17.)

wear, care should be taken to lubricate properly. An occasional washing with kerosene is advisable to remove the dirt, which will cause a poor contact.

11. A very frequent cause of skipping which is sometimes hard to locate, is a poor ground connection at the timer. This very often happens after the machine has been in use some time and the shaft becomes worn. A spring attached to the motor and bearing upon the timer-shaft will overcome this trouble effectually.

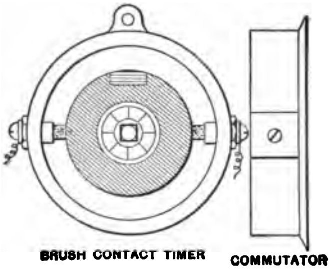


FIG. 25.

12. Starting a four-cylinder motor "on spark" is accomplished in the following manner: When a four-cylinder motor comes to rest the cranks stand at from 60 to 90 degrees with relation to a vertical line, and as the timer had been making contact on or before center while running, the commutator pauses between the contact-points

(For questions to answers on this page, see pp. 17, 18.)

as it comes to rest. Retarding the spark-lever rotates the timer, which follows the piston, and making contact ignites the charge retained in the cylinder. The spark-lever is immediately advanced to neutral and the next cylinder fires on center.

13. On all four-cylinder cars which start "on spark," neutral position of the spark-lever, which is about midway between retarded and advanced position, ignites the charge on center. In starting a four-cylinder car by cranking, the spark-lever should be retarded only partly from neutral position to avoid a back kick.

14. In setting a timer on a four-cylinder car, crank the motor and let it come to rest, advance the spark-lever one notch from retard, and set the timer just making contact with the proper coil to fire the cylinder retaining the charge. Fasten the rotor of the timer and close the switch. Retard the spark and if the contact is made the motor will run. If the motor does not start, the timer is not at fault.

15. Upon the timer construction satisfactory ignition at high speeds depends. As there is an interval of time required for the electrical current to rise to its full value and thus produce a good spark, the duration of timer contact must be long enough at high engine speeds to secure this result without being too long in contact at low speeds. If the timer works

satisfactorily when new, it can be kept in that condition only by care and attention from the operator.

LOW-TENSION IGNITION

1. The low-tension system of ignition is so-called because an electrical current of low voltage is used to produce a spark within the cylinder.

2. The current may be derived from either dry cells, storage-batteries, or a magneto, although the magneto is the usual source of current.

3. Either alternating or direct current may be used, and the voltage depends upon the speed of the armature of the magneto, ranging from 4 to 20 volts.

4. When either storage or dry batteries are used, a spark-coil is necessary, but when a magneto is used the armature-winding serves the same purpose.

5. A stationary electrode is insulated and inserted within the cylinder. Another electrode having an arm within the cylinder placed conveniently near is capable of being moved from the outside of the cylinder into contact within the cylinder with the stationary insulated electrode and then rapidly separated.

(For questions to answers on this page, see p. 18.)

6. The movable electrode is not insulated from the motor, and when it makes contact with the insulated electrode the electrical circuit is completed through the motor back to the source of current.

7. The spark which is created by the rapid separation of the points in contact is the result of the self-induced current of the spark-coil or armature-winding prolonging the flow of electricity which follows the moving electrode.

8. Platinum or iridium points are used for contacts, because these metals resist the oxidizing effect of electricity and heat better than other metals.

9. The duration of contact to create a spark depends upon the strength of current, and with batteries as a source of current must be longer than with a magneto, which results in imposing heavy duty upon the batteries.

10. As a considerable interval of time is required for the electrical current to rise to its full value and the instant of separation of the contacts must be not sooner than full-current strength has been attained, a greater proportionate drain on battery current will result at low speed than at high speed.

11. With magneto ignition the current strength is proportionate to the speed of engine, and the contacts can be of much shorter duration at high speeds than when batteries are used.

(For questions to answers on this page, see pp. 18, 19.)

12. The actuating mechanism for low-tension ignition systems is of the simplest form on some cars and more complicated on others, but the results desired and obtained in either case are proper duration of contact and rapid separation of the points at the proper time with relation to the position of the piston within the cylinder.

13. One of the simplest methods of make-and-break ignition consists of a cam actuating a push-rod which through the medium of a spring moves the points into contact and separates them again, the rapidity of movement depending upon the shape of the cam and the speed of the motor.

14. Another method is to move the points into contact by an eccentrically operated finger which trips at the proper point and allows the points to be rapidly separated by a spring.

15. The insulation of the stationary electrode is easily maintained because of the low voltage of the current carried.

16. In timing the low-tension or make-and-break system of ignition, retard the spark-lever, place the cranks on dead-center, move the electrode into contact and almost to the point of breaking the contact, and adjust in this position. A slight movement of the crank-shaft will cause the points to separate and the spark occurs just as the piston starts on its outward travel.

17. Advancing the spark is accomplished by

(For questions to answers on this page, see p. 19.)

causing the separation of the contacts to occur earlier with relation to the position of the piston, either by causing the actuating finger to trip earlier or by changing the position of the driving-gear on the shaft carrying the actuating cams.

18. With a magneto generating the current for ignition, as the engine increases in speed the strength of the current increases, but the exact point at which the current strength reaches the maximum is later with relation to the position of the piston within the cylinder. This does not materially affect the power of the spark, because the current strength is sufficient.

19. On a multicylinder motor no other contact can be made at the moment of break in one cylinder, because the current instead of creating a spark at the break would find a path through the other sparker and would not ignite the charge.

20. All the insulated electrodes in a multicylinder motor are connected together in series with the source of current usually by a strip of metal or a wire, and the other side of the source of current is grounded on the motor, thus completing the circuit with a very small amount of wiring.

MAGNETOS

(For questions to answers on this page, see p. 19.)

1. The fields of a dynamo are electrically excited; that is, a part of the current generated in the armature goes through the field-windings and creates an electrical field. In a magneto the electrical field is created by permanent magnets, which are composed of horseshoe-shaped pieces of flat steel which have been magnetized.

2. A flat steel bar after it has been bent into shape and hardened is wound with a great many turns of insulated copper wire and a current is passed along the wire until the saturation of the metal is as complete as it is practicable.

Saturation is never actually complete.

3. If the magneto is run on open circuit—that is, the current generated by the magneto does not return to it—(Fig. 26) the magnets will become demagnetized.

4. If the magnets have become demagnetized it will be noticed upon turning the armature by hand that there is very little resistance to its rotation. If the magnets are strong considerable resistance to rotation can be felt each half a revolution.

5. Permanent magnets which have lost their strength can be remagnetized by the same process in which they were first magnetized.

(For questions to answers on this page, see p. 19.)

6. Care must be taken in remagnetizing that the current be applied in the proper direction, for if the current is applied in the direction opposite to that in which the magnets were first magnetized the result would be a complete demagnetization.

7. To find the north pole of a magnet secure a compass and upon the approach of the magnet the north-seeking needle of the compass will be attracted by the north pole of the magnet. Then connect the positive terminal of the dynamo to that end of the wire which will conduct the current in the same direction that a right-hand screw turned in that direction would advance toward the north pole. In other

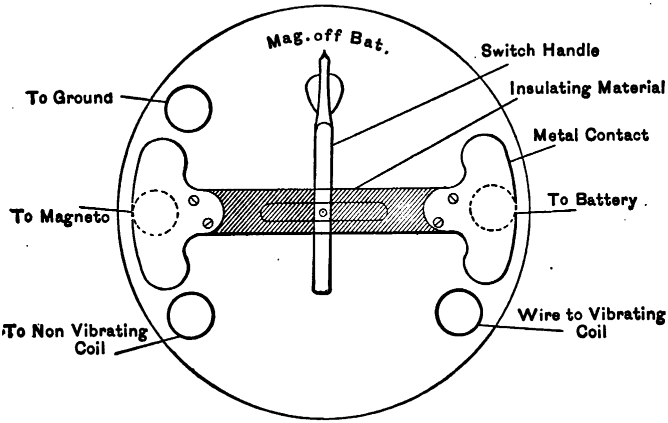


FIG. 26.—Construction of switch to be used with magneto and battery ignition.

(For questions to answers on this page, see p. 20.)

words, if the winding of wire started at the south pole and was wound around the magneto toward the north pole in a clockwise or right-hand direction the positive terminal of the dynamo would be connected at the south pole. If the wire was wound in a left-hand direction, the positive terminal of the dynamo should be connected at the other end of the wire.

8. Alternating and direct currents are both used in automobile ignition.

9. The current given off by magnetos is usually of the alternating system.

10. The dynamos in use are usually of the direct type, giving a direct current.

11. The kind of current given off by a magneto or dynamo depends upon the commutator and winding. It can be either direct or alternating.

12. A commutator is that part of a magneto or dynamo from which the current is taken which causes the alternating currents produced in the armature to flow in one direction, giving a direct current.

13. An armature is that part of a magneto or dynamo which rotates within the electrical field.

14. The opening between the ends of the permanent magnets in which the armature rotates is called the electrical field or magnetic field.

(For questions to answers on this page, see p. 20.)

15. Lines of force are said to emanate from the north pole and travel across the intervening space entering the south pole of a magnet.

16. The armature being wound with wire in the shape of a coil (as a skein of yarn is wound), the current is generated within it by cutting the lines of force of which the electrical field is composed by being rotated between the ends of the magnets.

17. As the magneto of the alternating type gives two impulses of current in opposite directions every revolution of the armature, it should be run at the same speed as the crank-shaft to furnish a current for a four-cylinder motor.

18. The direction in which the armature revolves makes no difference.

19. The circuit should be broken at a time when the current generated by the magneto is greatest.

20. The strength of current generated by a magneto depends upon the rapidity with which the lines of force are cut by the armature windings. Thus the faster the armature is rotated, the greater will be the strength of current.

21. As the current rises twice to maximum and as many times falls to zero during one revolution, there are two points of rotation of the armature at which the maximum current is obtained, and it is desired to have the spark occur at a time when the maximum output is

(For questions to answers on this page, see pp. 20, 21.)

being received from the magneto. Therefore the armature is advanced with relation to the crank-shaft so that this result may be accomplished.

22. Running a magneto on open circuit demagnetizes the magnets very rapidly, and the car should be so wired (Fig. 27) to prevent this when another source of current is used.

23. A low-tension magneto is one in which an armature containing a single winding is employed.

24. A high-tension magneto is one in which two sets of windings (primary and secondary) are employed upon the armature.

25. By providing an induction-coil the low-tension magneto may be used to generate current for a high-tension jump-spark system.

26. As a magneto gives out a current whose strength is dependent upon the speed of rotation, at high speed it would give a current altogether too strong for a vibrating spark-coil and the vibrator would stick on the core.

27. In the type of magneto having a stationary armature and magnets the lines of force are cut by a rotating sleeve having openings at opposite sides, which surrounds the armature.

28. A shuttle-type armature is one in which the windings are laid in one groove cut out of the armature core

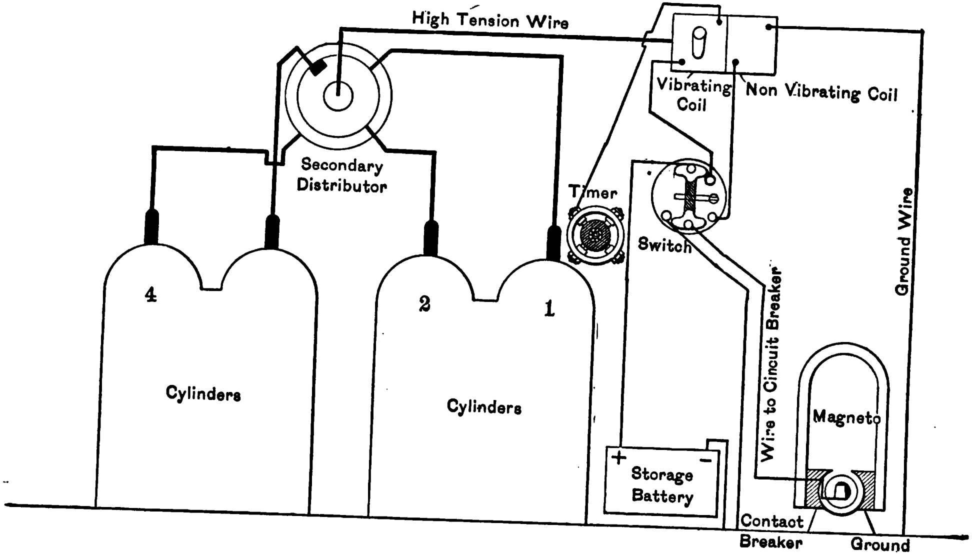


FIG. 27.—Wiring diagram showing method of connecting magneto in short circuit when using batteries.

(For questions to answers on this page, see p. 21.)

29. On machines using make-and-break sparking devices the armature winding takes the place of a coil and no spark-coil is necessary.

DRY BATTERIES

1. Dry cells are composed of a zinc cup, forming the negative electrode or pole. Within this is placed several layers of blotting-paper or some such absorbent material. In the center is placed a carbon rod, forming the positive electrode or pole. The intervening space is filled with carbon (ground coke) and dioxide of manganese. A liquid is then poured in and absorbed by the blotting-paper. The top is then sealed with a compound.

2. The above is a description of a cell.

3. A battery is two or more cells joined together.

4. Connecting the positive pole of one cell to the negative pole of another cell is called series connection.

5. Series connections (Fig. 28) add the voltage of each cell; that is, the voltage of the battery will equal the sum of the voltage of each cell.

6. Connecting the positive terminal of one cell with the positive terminal of another cell and the

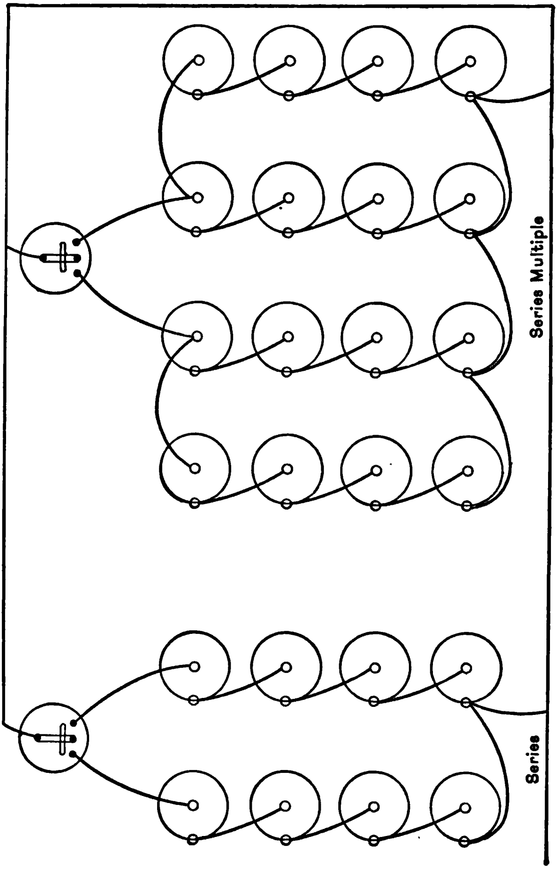


FIG. 29.

FIG. 28.

Connections of dry cells.

(For questions to answers on this page, see pp. 21, 22.)

negative terminal of the first cell with the negative terminal of the second cell is called a multiple or parallel connection.

7. A multiple or parallel connection adds the amperage of each cell; that is, the amperage of the battery will equal the sum of the amperage of each cell.

8. The amperage of a battery connected in series equals the sum of the amperage of each cell divided by the number of cells in the battery.

9. In connecting two cells or batteries together in multiple or parallel (Fig. 30) the voltage of each must be equal or the batteries will be run down.

10. Connecting eight cells in two sets of four in series and then connecting the two sets in multiple will give only six volts. This is called a series-multiple connection.

11. Should twenty-four cells be connected, four cells in each series, and then the six series connected in multiple (Fig. 29) would give only six volts.

12. The number of volts necessary for the proper working of the average coil is six, which can be obtained from four dry cells.

13. As a series connection adds the voltage of each cell nothing will be gained by connecting a greater number than four in series.

14. The advantage of the multiple connection

(For questions to answers on this page, see p. 22.)

is that the amperage is increased but the voltage is not.

15. By keeping dry cells packed tightly in a case and free from moisture and heat their life can be prolonged.

16. When more than one set of batteries are used the switches have a connection for each battery. This kind of a switch is called a two-pole, three-pole, etc.

17. The average voltage of a dry cell when new is 1½ volts.

18. The amperage of a dry cell when new ranges from fifteen to thirty amperes, according to the make.

19. When the amperage of a cell is reduced below five amperes it cannot be relied upon.

20. Dry cells should be tested with an ammeter, care being taken not to hold the ammeter on but a moment, as the ammeter being of very low resistance short-circuits the battery.

21. A voltmeter is not used in testing dry cells because while the cells are not giving out current their voltage remains practically the same, and a cell that is very weak will show nearly 1½ volts.

22. The reason dry cells deteriorate when not in use is because the moisture evaporates. A dry cell is not, strictly speaking, dry, but depends for its current upon moisture. Freezing, exposure to heat, and vibration (which

(For questions to answers on this page, see pp. 22–23.)

loosens the sealing) cause the moisture to evaporate.

23. An emergency dry cell has lately been put upon the market in which the moisture is supplied by filling the cell with water when needed.

24. By exposing the paper covers and insulation of the dry cells to moisture, the current leaks across from one cell to another, resulting in running down the battery.

25. In connecting dry cells to one another for use in an automobile, heavy copper wire should not be used, because vibration will cause it to break.

26. The best method of keeping battery connections tight is to wind a small rubber band around the terminal post under the nut.

27. The negative side of a battery is grounded to the frame or the motor, because the quantity of metal composing the frame and motor offers less resistance to the flow of electrical current than does a wire.

STORAGE-BATTERIES

1. A storage-battery, sometimes called accumulator, is one in which an electromotive force is generated or stored by the chemical action caused by sending an electric current through the matter of which the battery is composed.

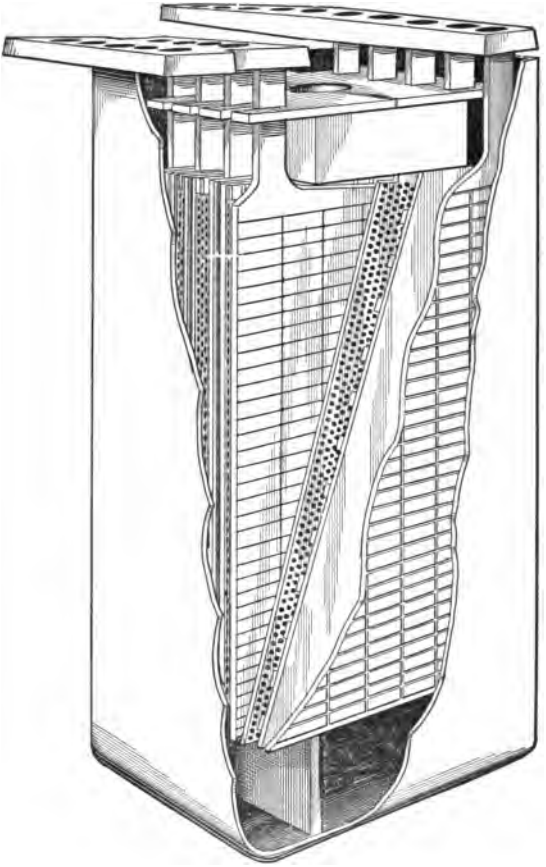


Fig. 30.—Storage-battery.

(For questions to answers on this page, see p. 23.)

2. Storage-batteries are of two types: those having formed plates, which is a process of chemically changing the composition of the plates, and those having the composition pasted into suitable perforations in the plates (Fig. 30). The first is called the Planté system, and the latter the Faure system. The batteries in use for automobile ignition are of the latter variety.

3. The cell is composed of an odd number of positive plates and an even number of negative plates immersed in a liquid called electrolyte.

4. The electrolyte is composed of approximately five parts of distilled water and one part of chemically pure sulphuric acid.

5. In mixing the electrolyte for a storage-battery the acid should be added slowly to the water. NEVER POUR WATER INTO ACID, as great heat is generated and it is liable to cause an explosion which would endanger your life. Acid stains on the clothing can be neutralized by a prompt application of ammonia.

6. The electrolyte must always cover the plates about ½ inch. If the electrolyte is too low, water should be added to make up for the loss due to evaporation. The acid does not evaporate.

7. If the electrolyte be spilled water should be added, and then at the completion of the charge, and only when the battery is FULLY CHARGED, should stronger electrolyte be added.

(For questions to answers on this page, see p. 23.)

The charge should then be continued a short time to mix the electrolyte.

8. Specific gravity is based on the unit of the weight of water; that is, one cubic foot of water at a temperature of 60° F. weighs 1,000 ounces, a unit or basis of 1, written 1.000, and read "one and no one-thousandths." Sulphuric acid weighs 1,840 ounces per cubic foot. The specific gravity of sulphuric acid is 1.840, written with a decimal and read "one and eight hundred and forty one-thousandths."

9. The specific-gravity test is made by a hydrometer and determines the weight of the electrolyte in relation to the same volume of water.

10. A hydrometer is an instrument for determining the specific gravity of liquids (Fig 31), and consists of a glass bulb having a graduated stem. The bulb is weighted at its lower end with shot.

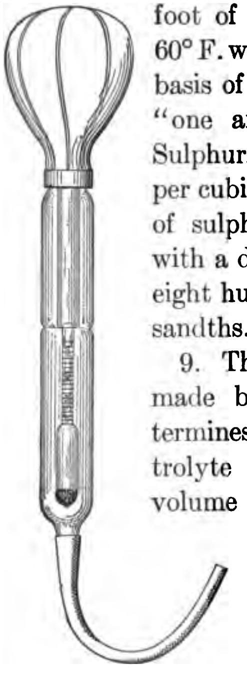


Fig. 31.—A hydrometer and syringe.

11. A hydrometer test is made by drawing out enough of the electrolyte by means of a syringe to float the hydrometer in a small jar. To

obtain a correct reading, the hydrometer must not touch the sides of the jar.

12. When the battery is first made and assembled the electrolyte is put in at about 1.080 specific gravity and rises as the charge progresses.

13. If the specific gravity of the electrolyte is low when the battery is fully charged its density should be increased by adding electrolyte of 1.400 degrees specific gravity. Acid of 1.400 degrees specific gravity can be purchased at a very low cost, and this is better to use in any case than to mix acid and water.

14. Comparison of the degrees of Baumé's hydrometer with the specific gravity of liquids:

Degrees Baumé.	Specific Gravity.	Degrees Baumé.	Specific Gravity.
20	1.160	31	1.267
21	1.169	32	1.277
22	1.178	33	1.288
23	1.188	34	1.299
24	1.197	35	1.310
25	1.206	36	1.322
26	1.216	37	1.333
27	1.226	38	1.345
28	1.236	39	1.357
29	1.246	40	1.370
30	1.256		

15. The specific gravity of the electrolyte in a storage-battery when fully charged should be

(For questions to answers on this page, see p. 24.)

1.250, or 29° Baumé. In some batteries it is 1.300, or 34° Baumé.

16. A test of the specific gravity of the electrolyte of a battery is the most accurate and will indicate the state of a battery at any time, providing the electrolyte is of the proper specific gravity when fully charged.

17. The electrolyte having a specific gravity of 1.250 when fully charged, when discharged to 1.7 volts per cell would read about 1.100. Then the difference between 1.250 and 1.100 divided by the ampere-hour capacity will give the number of degrees specific gravity to 1 ampere.

18. The first charge of a storage-battery changes the chemical composition of the active material contained within the plates and raises the specific gravity of the electrolyte. This description is not complete, and cannot be explained without considerable knowledge of chemistry, but will serve to show in a way the operation of the charge.

19. The discharge of a storage-battery is the reversal of the action which takes place in charging and the plates regain their first formation to a certain extent.

20. The current flows into a battery while charging by way of the positive pole.

21. In discharging the current flows out of the battery by way of the positive pole.

(For questions to answers on this page, see p. 24.)

22. The voltage of the charging current must be greater than the combined voltage of the cells, otherwise the battery would charge the dynamo, effecting a discharge of the battery.

23. An alternating current cannot be used to charge a battery for the reason that the current is first in one direction and then in the other, which would result in not increasing the charge in the battery.

24. Should the positive charging wire be attached to the negative terminal of the battery the effect would be a discharge assisted by the incoming current, resulting in a reversal of the action of the battery, which is very injurious.

25. The polarity of the charging wire may be found by immersing one-half inch apart the ends of both wires in a cup of water to which a little salt or vinegar has been added. Bubbles will be noticed forming on the ends of both wires. The one having the greatest number of bubbles is the negative wire, the other is the positive wire. The positive wire being of copper will blacken, the negative wire remains bright. Blue litmus paper can be used also. By placing a strip of this paper in a shallow dish containing water, then touching the wires to each end of the paper simultaneously, the negative wire will turn red.

26. The best current for charging is furnished by a dynamo whose voltage can be regulated

(For questions to answers on this page, see p. 24.)

to the amount required for the battery. The 110-volt lighting circuit may be used by connecting incandescent lamps into the circuit in multiple in such a way that the only current that can reach the battery must pass through the lamps.

27. The first part of the charge of a storage-battery can be put in at the maximum rate, which equals the normal discharge rate. Three-quarters of the charge should be put in at this rate, the remaining quarter should be put in at approximately three-eighths of the maximum charging rate, which would be the minimum charging rate. Thus, if the maximum charging rate was eight, the minimum charging rate would be three. Ten per cent should be added to the charge for loss in charging.

28. The maximum charging rate is the number of amperes at which the current is put into the battery during the first part of the charge, or until three-quarters of the necessary charge is reached. For example, if a battery of 60 ampere-hours capacity were half discharged, 30 plus 10%, equaling 33 ampere-hours, should be put into it. The maximum charging rate of a 60-ampere-hour battery being 7½ amperes, 7½ amperes should be supplied for three hours and twenty minutes, which would equal 24¾ amperes, or three-quarters of the charge. The amperage should then be cut down to three-

eighths of the maximum charging rate, which is (the minimum charging rate) approximately 2¾ amperes. Continue the charge for three hours, at which time the battery should be fully charged, having received 33 ampere-hours.

29. Charging at a high rate, especially during the latter part of the charge, raises the temperature and causes the plates to buckle, due to the rapid expansion of the active material within them. Buckling results in distorting the plates containing the active material, causing it to fall out and drop to the bottom, or sometimes lodge between the plates, short-circuiting them.

30. The charging rate of a new battery on the initial charge should be not more than a two-ampere-hour rate.

31. A battery should be charged every two weeks whether used or not.

32. A battery should be discharged to one and seven-tenths volts and immediately recharged every two months in order to displace and replace all of the active material and give it a new grip upon the plates. This will preserve the maximum output.

33. In order to give its maximum output a battery should be regularly discharged and charged. If it is kept fully charged at all times, only a part of the active material is at work, and it loses its grip, as it were, upon the plates.

(For questions to answers on this page, see p. 25.)

It can be likened unto a person always keeping his stomach full of food, which will in a short time impair his digestive organs.

34. The discharge of a storage-battery can be accomplished by immersing in slightly acidulated water contained in an earthenware jar, two iron plates being suspended at the top to which are connected the terminals of the battery. By moving the plates nearer to or farther from each other the proper amount of current can be drawn from the battery as indicated by an ammeter, which can be connected in circuit. (Attach one end of the ammeter to the battery, the other end to the plate immersed in the liquid.)

35. Allowing a battery to stand in a discharged condition will cause the formation of free sulphates, which will deposit upon the plates and insulate the active material from them, thus reducing the capacity of the battery.

36. By a long-continued charge at a low rate the sulphates, due to overdischarge, can be broken down and the battery improved somewhat, but it is better to avoid the cause than to resort to this means of overcoming it.

37. In a healthy battery the positive plates when fully charged have a dark chocolate color. The negative plates are somewhat lighter and their color may be called a dark lead color. Sulphates are white and a deposit of sulphates

(For questions to answers on this page, see p. 25.)

upon the plates will make their color very much lighter, and the positive plates instead of being dark chocolate will become a light brown, almost a yellow.

38. When the voltage of each cell of a battery which is charging at the minimum rate reaches two and five-tenths volts the battery is fully charged. Note.—When charging at the maximum rate the voltage will be 2.5 volts before full charge is reached. When the charging current is reduced to the minimum rate the voltage will drop and rise again.

39. Another way to determine full charge of a battery is by a hydrometer test, together with a voltage test. When for half an hour the specific gravity and voltage of the charging battery does not rise, the charge is complete. Nearing the point of full charge will be indicated by the milky appearance of the electrolyte, and by the giving off of gas rapidly.

40. Electrolyte should be added only upon the completion of the charge.

41. Acid must not be added in its pure state to a battery, but only after being diluted with water to 1.400 specific gravity and cooled.

42. The temperature should not rise above 100° F. while charging. Should the temperature while charging become excessive, the current strength should be reduced or the charging

(For questions to answers on this page, see pp. 25, 26.)

stopped for a time. Overheating is caused very often by the plates being sulphated.

43. It is necessary to remove the vent-caps to allow the free escape of gas which is formed while the battery is charging. While discharging the battery should never be shut up tight. Always leave a small opening for the escape of gas, although it need not be so large as when the battery is charging.

44. While charging the battery gives off a quantity of inflammable gas, and should a naked flame be brought in contact with it an explosion would occur, which would doubtless ruin the battery, also endangering the life of the person.

45. The voltage of one cell of a storage-battery is commonly called 2, but while standing idle a voltmeter test will record 2.2. No matter how large a cell is the voltage is no greater than in a smaller cell, and a voltage test of an idle battery is of no value.

46. The amperage of a single cell depends upon the size and number of the plates. The larger or greater number of the plates the more amperage there will be.

47. A voltmeter is an instrument for measuring the force of an electrical current.

48. An ammeter is an instrument for measuring the rate of flow of an electrical current.

49. Only when drawing the normal output

(For questions to answers on this page, see p. 26.)

from a battery, or when charging at the minimum rate, can a correct voltmeter reading be taken.

50. The normal output of a battery, unless otherwise specified, is the ampere-hour capacity divided by 8, which means that one-eighth of the capacity can be drawn out steadily for eight hours.

51. The ampere-hour capacity is the amount that can be drawn out in eight hours' flowing at a steady rate.

52. The number and size of plates composing a storage-battery regulate the ampere-hour capacity. By discharging the battery at a steady rate for eight hours, the ampere-hour capacity will be the product of the discharge in amperes multiplied by the number of hours. If the battery is discharged in more than eight hours a greater current can be drawn.

53. Testing a storage-battery with an ammeter is ruinous both to the battery and the ammeter. You might just as well try to test it with a wire as far as results are concerned.

54. The corrosion of a greenish color which sometimes collects on the battery terminals is caused by the chemical action of the electrolyte upon the brass or copper terminals.

55. The top of a battery being wet with acid, the terminals become moistened and a corrosive action takes place. The corrosion can be

(For questions to answers on this page, see p. 26.)

removed by wiping with a cloth moistened in ammonia or water. The terminals should be cleaned thoroughly and covered either with paraffin wax or vaseline to keep the acid away from them.

56. Should a terminal nut be corroded so that it could not be removed without considerable force, do not twist off the screw. Instead place a piece of asbestos board over the cell, having the terminal projecting through a hole in it, then with a hot iron or small flame from a blow-torch heat the terminal, (taking care not to get it hot enough to melt the lead). The heat will loosen up the corrosion and the nut can be removed easily with a pair of pliers.

57. Connections between cells should be fused. They should never be soldered, as the electrolyte will destroy the solder in a short time and the joint will separate.

LUBRICATION

1. Lubricating-oil forms a film between the metal surfaces of a bearing, thus keeping them apart and permitting them to run with very little friction.

2. With too little lubrication the metal surfaces will rub together, causing great friction, heat, and wear, which will be indicated by a

loss of power, heating of the parts, and sometimes a squeak.

3. Overlubrication of a bearing has no harmful effect upon it, but is wasteful of oil and covers the surrounding metal with a coating of oil which gathers dirt, and is unsightly.

4. Overlubrication of the piston and cylinder, deposits upon the walls of the combustion-chamber and head of the piston a sooty carbon, which when hot causes premature firing of the charge and overheating of the cylinder generally and is liable to short circuit the spark-plug.

5. For cylinder lubrication the oil should have sufficient viscosity, which is its ability to maintain a perfectly even film; should contain very little carbon, which may deposit upon the combustion-chamber walls; should be free from harmful acids, which would attack the metal, and be of sufficiently high fire test to thoroughly lubricate the cylinder walls, but low enough to permit that which gets into the combustion-chamber to burn and pass out with the exhaust.

6. There are four methods of lubrication in general use: the gravity system, wherein the lubricator is sufficiently elevated to allow the oil to flow to the bearings; the pressure feed, which is a tank containing the oil under a pressure, which may be secured by leading into it a small pipe from the exhaust, or by utilizing pressure from an enclosed crank-case; the posi-

(For questions to answers on this page, see p. 27.)

tive method in which a certain amount of oil is forced through the pipes by the action of a pump or pumps, and the splash system, which consists of a level of oil maintained in the crank-case, which by the rapid motion of the cranks and connecting-rods forms a mist and envelops the parts.

7. In the pressure and elevated system the opening through which the oil flows is adjustable by means of a needle. In the positive system the stroke of the pump or pumps is adjustable by various methods. In the splash system, sufficient oil is supplied at intervals to maintain the level at a predetermined height, which in usual cases permits the connecting-rod to dip into it not more than one-quarter of an inch while at its lowest point.

8. The absence of oil allows the metal surfaces to come into contact with each other and through friction become heated. When sufficiently hot they seize each other and the power being sufficient tears them apart again. Particles are torn from one or the other, which being carried around cut rings or grooves in each surface. Should the cutting continue for a period the oil-channel which distributes the oil equally over the surface would be cut through and effectually prevent lubrication from being distributed over the surface again should it be applied later.

(For questions to answers on this page, see p. 27.)

9. Should it be found that a bearing through lack of lubrication had become heated although it had been discovered before serious injury had been done to the bearing it would be necessary to take the bearing apart in order to thoroughly lubricate again. The reason for this is that as the bearing becomes heated the lubrication that remains in the distributing groove burns and fills the groove with a non-lubricating material. This must be cleaned out before lubrication of the bearing can be accomplished.

10. It will be interesting to note that as a bearing fails to receive proper lubrication the last of the oil will form where the greatest pressure is and will force the bearing to the other side. If the pressure or weight is downward the top will cut first. In the case of a horizontal engine the piston and cylinder would be cut at the top by the piston being raised by the oil, even though its weight rested on the under side.

11. In the case of a connecting-rod or similar bearing having a divided bushing, the bushing can be removed and with a fine-cut half-round file the grooves or ridges can be removed, taking care not to go deeper than is necessary, and then it can be scraped to fit the shaft with a steel scraper. The ridges and grooves must be removed in a like manner from the shaft, leaving it perfectly smooth and round. In order to

(For questions to answers on this page, see p. 27).

detect any unevenness in the shaft or bushing a little red lead or fine chalk can be rubbed upon the shaft, the bushing clamped around it, and then by turning the shaft in the bushing the paint or chalk will be worn from the shaft and the bushing where it wears hardest and these spaces will be bright. This operation can be repeated, alternately scraping and testing until no bright spots appear. Refitting a bearing necessitates considerable labor, and is better entrusted to some one who has had some experience in this line of work.

12. Soft-metal bearings are quite generally used for connecting-rods, crank-shaft bearings, and the like. Some of the advantages of a soft-metal bearing are a reduction of friction, less cost to replace and manufacture, and when through lack of lubrication they become hot will melt and run out without injuring the more expensive shaft.

13. Front wheels having roller or ball bearings should be packed with grease, commonly called " dope," every 1,000 miles.

14. The differential gear should be filled every 500 miles with grease which has been mixed with oil while hot, being about the consistency of thick cream.

15. A change-speed gear of the planetary type should be filled with a medium-bodied lubricating-oil, not a grease, and the case should

be tight enough to retain the oil without undue waste. A sliding-gear transmission-case should contain oil not heavier than the consistency of thick cream up to the smallest gear on the shaft. Filling higher than this gear is a waste of oil, because it is liable to run out through the bearings. Heavy grease should not be used in a sliding-gear transmission because the shaft-bearings will suffer until the case gets warm enough for the grease to become semi-fluid. Individual clutch type of transmission should not be lubricated with heavy oil because too great pressure will be necessary to force the oil from the clutches before they are properly engaged.

16. On a day set aside for that purpose in each week, preferably Saturday, because a long run is usually taken Sunday, every part of the car should be gone over and lubricated, at the same time testing the working of the mechanical oiler. When driving more than 500 miles a week a car should be examined each night after the run and properly lubricate each part whether it moves once a day or is continually moving.

17. With an engine running 500 revolutions per minute, each cylinder should receive from three to four fair-sized drops per minute. With a force-feed, which is usually geared at about one stroke of the pump to every eighty revolutions of the crank-shaft, the lubricator should

(For questions to answers on this page, see pp. 27, 28.)

draw one fair-sized drop for each cylinder. Where splash lubrication is used three drops per stroke of the pump will maintain the oil level if the case is tight.

18. Once each week the crank-case and transmission-case should be thoroughly washed out with kerosene-oil and new lubricating-oil put in. This upon first thought might seem unnecessary and a waste of lubrication, but actual experience has proven that it pays twofold in the end. The wearing of the parts deposit particles of metal in the bottom of the case and agitation of the oil carries them up into the bearings again, resulting in increased wear. The differential should be thoroughly washed out once each month and filled with new grease.

19. The action of gasoline on the bearings would be to remove all of the lubricant therefrom, which may not be supplied again until considerable damage has resulted. Kerosene has not such a harmful effect.

20. In cold weather, if the lubricator is of the gravity system, a low cold-test oil should be used or the regular oil should be diluted with a small quantity of kerosene. The cold-test oil is much better if it can be secured.

21. Any part which does not get warm from the heat of the engine can be lubricated by forcing grease to the bearing by means of a compression grease-cup.

(For questions to answers on this page, see p. 28.)

22. Compression grease-cups usually employed are of two kinds, those that require a turn every 25 miles or so, and those by which a piston forced against the grease by a spring feeds it to the bearings as required.

23. The oil in a multiple disk clutch should not completely fill the case or the oil cannot be disposed between the disks rapidly enough to permit their manipulation. In cold weather, oil diluted with kerosene in about the proportion of one-half of each should be used to insure the oil remaining fluid.

24. The leather face of the cone clutch should be treated occasionally with castor-oil to keep it in good condition. The leather should be soft and pliable at all times.

25. If the clutch slips because of too much oil, apply fullers' earth, sulphur, or any absorbent powder to the clutch surface to absorb the oil.

GOVERNORS

1. Governors as applied to automobile engines are for the purpose of maintaining a constant engine speed irrespective of the power required by varying road conditions.

2. The limit to which the governor can reduce the speed of the engine is under the control of

(For questions to answers on this page, see p. 28.)

the operator by means of a lever placed convenient to his hand, usually upon the steering-wheel.

3. An accelerator is a pedal placed within reach of the operator's foot, by which means the governor action is opposed, effecting a partial or complete opening of the throttle according to the pressure exerted upon it.

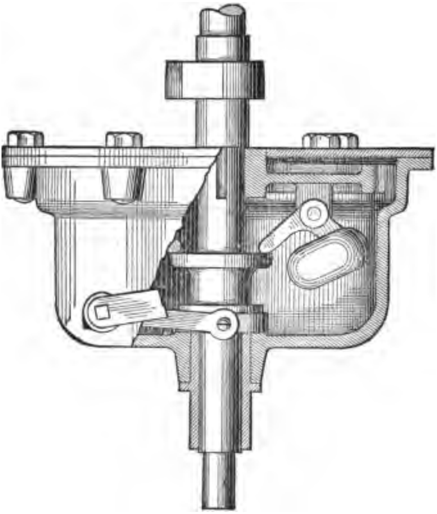


Fig. 32.—Ball type of centrifugal governor.

4. There are two kinds of governors in general use, centrifugal governors and pump-governors.

5. There are two kinds of centrifugal governors employed on automobiles, one having rapidly revolving weights or balls (Fig. 32)

which, due to centrifugal force, have a tendency to fly out from the shaft and overcome the tension of the spring which holds them normally to the shaft, and thus through suitable levers act upon the throttle-valve, regulating the amount of gas supplied to the engine. Another

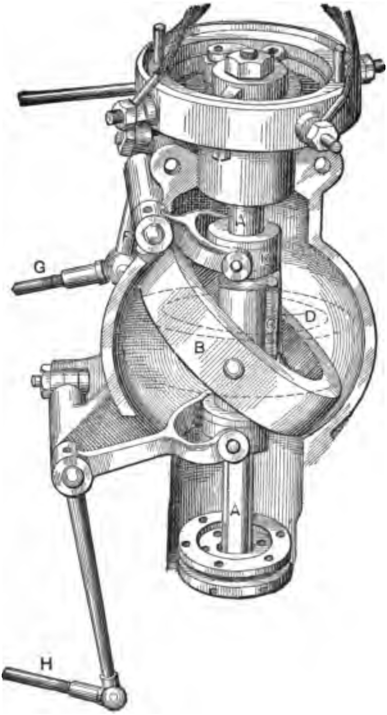


FIG. 33.—Wheel type of centrifugal governor.

(For questions to answers on this page, see p. 28.)

kind of centrifugal governor (Fig. 34) is a heavy pivoted wheel which is normally held by a spring at an acute angle with relation to its shaft. The centrifugal force overcomes the spring tension and the wheel has a tendency to dispose itself at right angles to the shaft, thus through suitable levers the gas admitted to the cylinders is regulated.

6. The pump form of governor depends upon the pressure of a liquid, either water or oil, against a flexible diaphragm or a piston. The pump in this form of governor being driven in direct relation to the engine speed, the amount of liquid forced against the diaphragm or piston varies with the engine speed, and through suitable levers the movement of the governor-piston or diaphragm regulates the amount of gas admitted to the cylinders.

7. By placing the governor containing a flexible diaphragm near the circulating-pump, the pressure will vary with the engine speed, and the cooling-water can be used for the governor.

8. The action of the governor regulates the amount of gas admitted to the cylinders, either by opening or closing a valve in the pipe leading from the carburetor to the inlet-valves or by regulating the amount and the duration of the opening of the inlet-valves. Governing by missed explosions or by retaining the exhaust,

(For questions to answers on this page, see p. 29.)

as is sometimes done in stationary engines, is not resorted to in the case of the automobile.

9. On one very successful and prominent make of automobile the inlet-valves are restricted in their opening by a varying air pressure supplied by a pump driven in direct relation to the engine speed.

10. The amount of air pressure on the inlet-valves is under the control of the operator, who by opening suitable valves relieves the pressure as desired.

11. The lever on the steering-wheel is connected to the centrifugal governor by means of a flexible spring whose tension the governor must overcome in order to reduce the power. The accelerator-pedal is connected direct without the intervention of a spring and its action on the governor is positive.

12. When the clutch is disengaged the speed of the engine increases and the governor closes the throttle by overcoming the tension of the spring attached to the lever on the steering-wheel.

13. In ascending a hill or traveling over a bit of road requiring more power, the engine speed decreases and the governor, which is assisted by the tension of the spring attached to the lever on the steering-wheel, opens the throttle, admitting more gas.

(For questions to answers on this page, see p. 29.)

14. In slowly traveling crowded streets where the noise of traffic prevents the operator from hearing the sound of the engine, the governor controls the admission of gas to the cylinder and prevents the engine from being stalled.

15. To protect the wearing parts from dirt and dust, and to prevent anything from coming in contact with the rapidly revolving arms, centrifugal governors are usually incased, which also facilitates the proper lubrication.

16. In a great many cases the centrifugal governor of the ball type is attached to and works within the cam-shaft gear, but as the cam-shaft rotates at only half the speed of the crank-shaft in a four-cycle engine, its action is less sensitive than a governor driven at the same speed as the crank-shaft, which is usually accomplished by driving from the crank-shaft with a chain, belt, or gear.

MUFFLERS

1. The muffler is for the purpose of silencing the noise of the exhaust.

2. The noise of exhaust is silenced either by breaking up the gases; or by allowing them to expand to atmospheric pressure; or by cooling them before they are admitted to the air.

(For questions to answers on this page, see p. 29.)

3. An expanding muffler (Fig. 34) is one in which the hot gases are allowed to expand to nearly the atmospheric pressure.

4 A separating muffler (Fig. 35) is one in which the gases are broken up or separated by passing through numbers of small holes in tortuous passages.

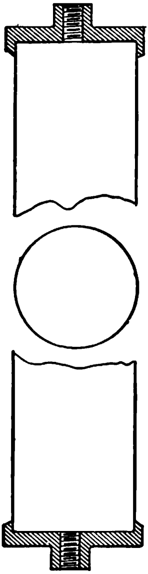


Fig. 34.—Expanding muffler.

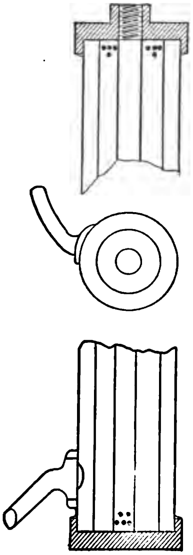


Fig. 35.—Separating muffler.

5. A cooling-muffler (Fig. 36) is one in which the hot gases are cooled, either by an increased surface exposed to a cooling air-draught or by cooling with water. This latter is little used.

(For questions to answers on this page, see pp. 29, 30.)

6. A muffler cut-out is a device by which the exhaust-pipe is opened, permitting the gases to escape without going through the muffler.

7. The reason the engine gives more power when the muffler is cut out is that there is less back pressure on the engine.

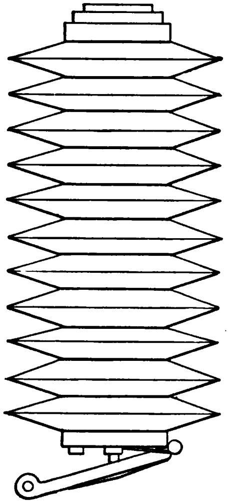


Fig. 36.—Cooling-muffler.

8. Back pressure means that the exhaust gases did not have a free passage, and at the time of the closing of the exhaust-valve they are retained in the cylinder under considerable pressure.

9. A partially stopped opening in the muffler will reduce the motor power by increasing the back pressure.

10. When a muffler is plugged up there is a continued hissing at the muffler and the beats of the motor are not clearly defined.

11. Muffler explosions are caused by igniting an unexploded charge by the flame of the following charge.

12. If the muffler is of ample capacity the explosion therein, unless it is completely filled with explosive gas, does no damage.

(For questions to answers on this page, see p. 30.)

13. Black smoke coming from the exhaust indicates that the mixture is too rich in gasoline.

TRANSMISSIONS

1. A planetary transmission (Fig. 37) is one in which the gears revolve around the shaft, at the same time revolving on their own axis, similar to the earth and sun movement.

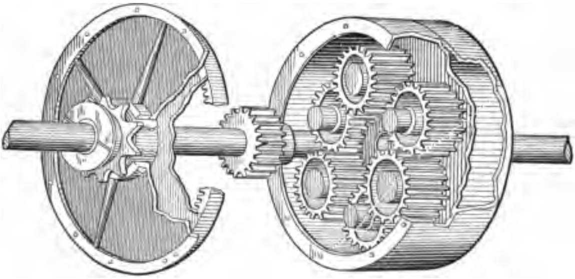


FIG. 37.—Planetary transmission.

2. The slow speed is obtained by contracting a frictional band upon the drum, preventing that part from rotating.

3. The reverse is obtained by holding another drum from rotating after releasing the slow speed.

4. The high gear is obtained by means of a friction-clutch attached to and running with the shaft. When forced into engagement with one

(For questions to answers on this page, see p. 30.)

of the drums, it locks the gear carried by the drum to the shaft and thus prevents the gears within the transmission from rotating, and the whole transmission revolves as a unit with the shaft.

5. Planetary transmissions as usually made have but two speeds forward.

6. One well-known manufacturer equips cars with a three-speed planetary transmission which is very successful though somewhat complicated.

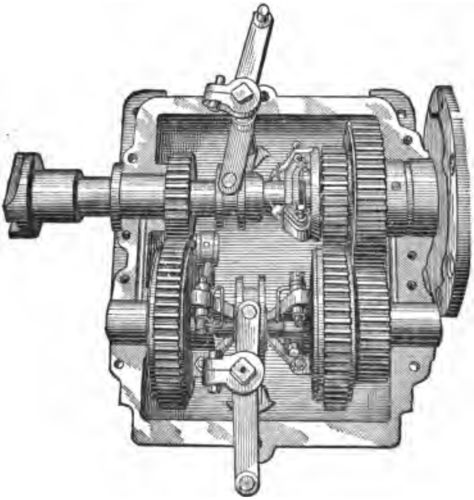


FIG. 38.—Individual clutch transmission.

7. The reverse-band of a planetary transmission can be used as a brake in cases of

(For questions to answers on this page, see pp. 30, 31.)

emergency, but unless the reverse-drum is locked to the shaft by the high-speed clutch, it should not be used while a high gear is engaged.

8. An individual clutch transmission (Fig. 38) is one in which the gears run idly on their shafts until engaged by a friction-clutch, which is attached to and runs with the shaft.

9. The slow speed is obtained by engaging a gear on the counter-shaft with its clutch and compelling it to rotate with the counter-shaft.

10. The reverse is obtained by engaging a gear on the counter-shaft with its clutch, into which an intermediate gear is running, thus reversing the direction of the driven gear.

11. The high gear is obtained by means of a clutch locking the transmission-shaft and drive-shaft together.

12. The use of the reverse-clutch as a brake is not good practice with this style of transmission, as it results in considerable wear on the clutch, and because of the opposite directions of rotation of clutch and gear when the machine is being driven forward by its momentum is not productive of good results in braking.

13. A sliding-gear transmission (Fig. 39) is one in which a gear or number of gears capable of being moved along one shaft makes engagement with other gears on a shaft parallel to it.

14. The slow speed is obtained by moving

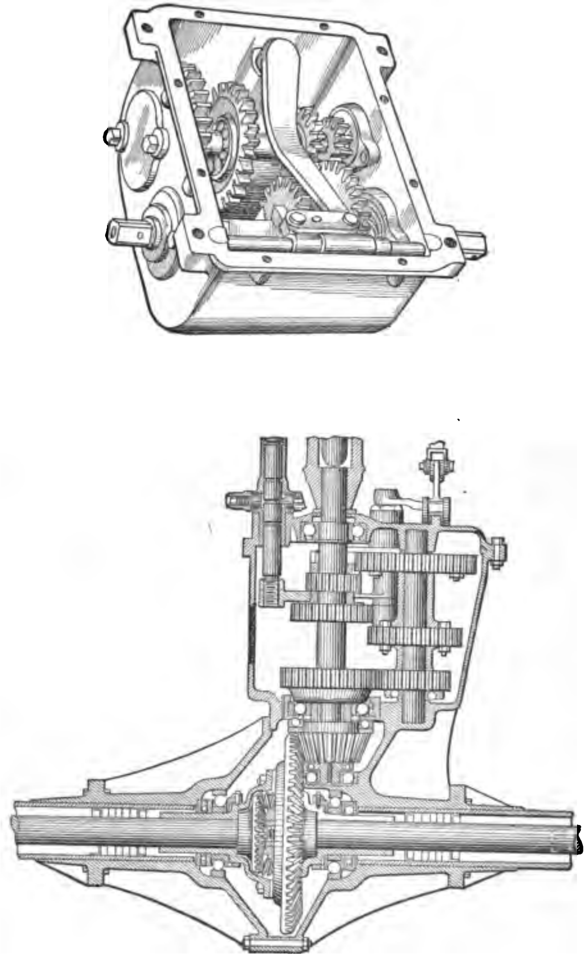


FIG. 39—Sliding-gear transmission.

(For questions to answers on this page, see p. 31.)

the sliding member of the gear-set into engagement with the smallest gear on the counter-shaft.

15. The second or intermediate speed is obtained by moving the sliding member into engagement with the next larger gear on the counter-shaft.

16. The high gear is obtained by moving the sliding member into engagement with a clutch or notched collar, thereby locking the clutch-shaft to the transmission-shaft, which now rotates at the same speed as the motor crank-shaft.

17. The reverse is obtained by interposing a small gear between the sliding member when it is in neutral position and low gear. This necessitates an extra lever or foot-pedal to bring the reverse-gear into engagement. Another way is to move the sliding member through the lowest forward gear into engagement with a small gear whose teeth are in mesh with a gear on the counter-shaft, which is smaller than the low-speed gear.

18. The reverse gear of a sliding-gear transmission cannot be used as a brake.

19. In using a sliding-gear transmission it is necessary to release the clutch before attempting to change gears. Care must also be taken to have the engine speed equal to the speed of the car when engaged in a certain gear; that is, when changing from low to second gear the

(For questions to answers on this page, see p. 31.)

engine speed must be reduced before letting in the clutch, and when changing from second to high gear as well. In reducing gear the engine speed must be increased when changing from high to second or from second to low, or a sufficient time must elapse between releasing the clutch and again engaging it to permit the speed of the car to reduce to the engine speed.

20. By engaging the low gear while the car is under considerable headway and suddenly letting in the clutch, the teeth of the gears are liable to be broken off, which is called stripping gears. Other causes of stripping gears are reversing the car while going forward, attempting to change without releasing the clutch, and by suddenly letting in the clutch with a high engine speed.

21. Engaging by clutch, notched collar, or other means the shaft to which the clutch is attached and driving direct to the rear wheels without gears is called direct drive on high gear, although other gears within the transmission may be engaged and running without transmitting any power.

22. A selective type of transmission is one in which the sliding member or members do not pass through the gears in which they are engaged. Thus a change may be made from high gear to low or opposite without passing through the intermediate gears.

(For questions to answers on this page, see pp. 31, 32.)

23. In changing from slow speed to second speed, the speed of the engine must equal the speed of the car.

24. In changing from high to second speed (reducing gear) the engine speed must be increased from the speed at which it was running while engaged in high gear before second gear is engaged.

25. In reversing a sliding-gear car care must be taken to have the car stopped before the direction is reversed.

26. In ascending a hill on the low gear the speed of the engine should be so regulated or controlled that it does not race. It is better to proceed slowly than to ruin the engine. A greater speed than 1500 revolutions is extremely injurious.

27. Coasting with a heavy car should be indulged in with caution.

28. A friction drive is one in which the power is transmitted by the friction of one wheel bearing against another. This style of transmission, unless operated very carefully, wears the frictional surfaces very rapidly, requiring frequent adjustment.

29. The reason for the wearing is the grinding motion of the wheels in contact, which is present at all times. For example, if the wheel having the friction surface had a contact of 2 inches, the edge nearest the center

(For questions to answers on this page, see p. 32.)

would be traveling a smaller circle than the edge farthest away from the center, which must result in a slipping and grinding action.

CLUTCHES

1. A clutch is a device permitting the engagement and disengagement of the driving mechanism from the motor.

2. There are numerous types of clutches, among which are the cone clutch, external contracting-clutch, internal expanding-clutch, and multiple-disk clutch.

3. The male member of a clutch, which is cone-shaped in the cone clutch, is usually faced with leather where it makes frictional contact with the female part, which is usually a part of the fly-wheel. The expanding clutch consists usually of a flexible band capable of being expanded against the inner periphery of the fly-wheel, usually faced with leather. A disk clutch is one having a number of metal disks alternately attached to the shaft and the fly-wheel, usually running in a bath of oil. A contractional clutch is one whose flexible band grips a cylindrical projection upon the fly-wheel by being contracted.

4. The clutch is usually placed between the motor and change-speed gear.

5. The clutch is operated usually by the

(For questions to answers on this page, see pp. 32, 33.)

pressure of the operator's foot upon a convenient pedal.

6. A strong spring usually holds the clutch in engagement when the car is traveling along the road, but must be held out by the operator when the car is at rest if the engine is running and the gears are not in a neutral position.

7. Unless the change-speed gears are not in engagement the car will start when the motor is started.

8. On many cars the act of applying the emergency brake disengages the clutch from the engine.

9. On a number of makes of cars either brake disengages the clutch, but on others the foot-brake can be applied while the clutch is engaged. This system is advantageous in starting the car on a grade because the brake can be applied until the clutch takes hold, thus preventing the car from starting downward.

10. A clutch should be engaged gently to avoid starting the car with a jerk, which is liable to stall the engine and strains the driving mechanism unduly.

11. If a clutch takes hold too quickly, caused from the leather being too dry, apply castor-oil to soften up the leather. If the female and male members are exactly the same taper, the whole surface of the clutch engages at once, and new leather should be applied to the

(For questions to answers on this page, see p. 33.)

cone, which being thicker at its inner edge will permit the clutch to take hold gently.

12. The remedy for a slipping clutch would depend upon the cause. If the leather is covered with oil, fullers' earth, talc, sulphur, or some such absorbent powder should be applied to absorb the oil. If the leather is dry it should be softened with castor-oil or tincture of myrrh should be applied. Resin should never be applied to slipping clutches. It will grip fiercely at first, but as it becomes warm it will slip worse than ever. If the spring is too light or has insufficient tension, the clutch will slip only at high speeds or when ascending a hill.

13. A clutch faced with leather when it slips will create considerable friction and will burn the leather. The metal-to-metal clutch will cut and wear rapidly.

14. Nearly all clutches are provided with a means for adjustment and care should be taken that they are properly adjusted to secure satisfactory results.

15. A clutch that does not fully release hinders the rapid change of gears on cars having sliding-gear transmission, heats up the clutch when the car is at rest with the engine running, and wears out the clutch rapidly.

16. The proper working of a metal multiple-disk clutch depends upon ample lubrication, thus permitting the disks to gradually take hold

(For questions to answers on this page, see p. 33)

as the oil is forced from between them by the pressure of the spring.

17. As this style of clutch is composed of a number of metal disks alternately attached to the motor-shaft and transmission-shaft, the act of forcing them into engagement with each other creates a friction proportionate to the size and number of the disks. As an experiment lay fifty sheets of paper on one another, having each alternate sheet projecting over the edge of the under one; place a paper-weight upon the pile and try to slide them apart by pulling on the ends; notic the resistance.

18. The oil contained in the clutch must be forced out from between the disks before the clutch takes hold sufficiently to start the car.

19. By providing a number of disks of small size more than one is necessary to start the car, and as the oil is gradually forced out from between them the car is started without a jerk.

20. In cold weather the oil in the clutch congeals and prevents the successful working of the clutch.

21. The oil should be mixed with equal parts of kerosene in winter to prevent it from thickening.

22. The case of a multiple-disk clutch should never be entirely filled with oil, because the oil displaced from between the disks has no room and the action of the clutch is not rapid enough,

(For questions to answers on this page, see pp. 33, 34.)

DIFFERENTIALS

1. A differential is a set of gears the purpose of which is to so distribute the power transmitted through them as to allow the driving-wheels of a car to travel at different speeds according to the resistance with which they meet in passing over the road.

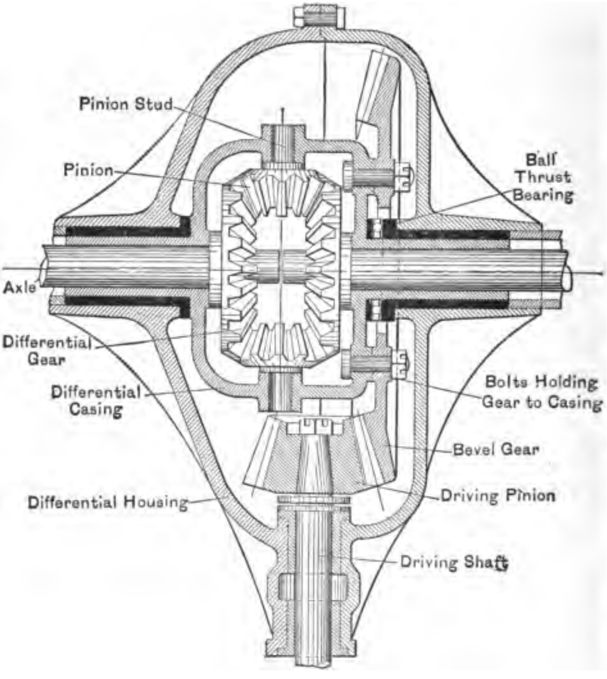


Fig. 40.

2. There are two kinds of differentials, the

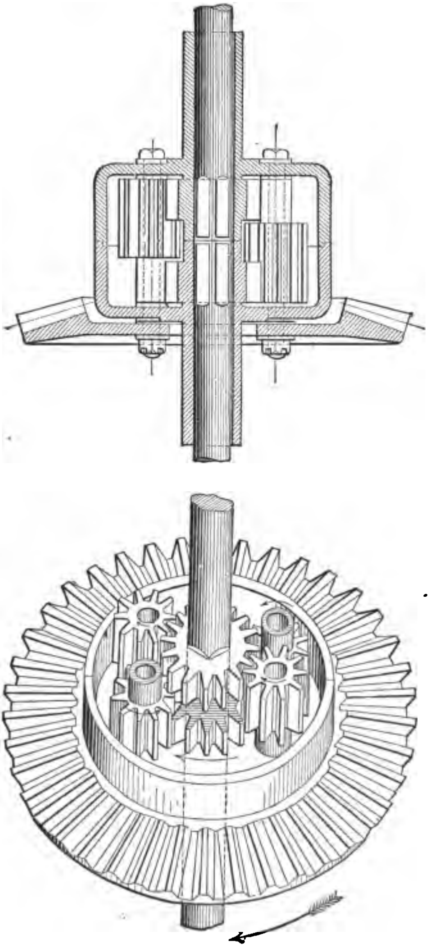


Fig. 41.

(For questions to answers on this page, see p. 34.)

bevel-gear (Fig. 40) and the spur-gear (Fig. 41) differential.

3. The differential of a chain-driven car has a large sprocket-wheel to which the chain is attached, and that of a shaft-driven car has a bevel-gear wheel which is in mesh with a bevel-gear pinion on the drive-shaft.

4. In a bevel-gear differential, bevel-gear wheels are used, and in a spur-gear differential spur-gear wheels are used.

5. On cars having a bevel-gear drive the outer casing of the differential forms a protection from the dust and retains the lubricating grease.

6. The differential case is a casing enclosing the differential gears and carrying the studs upon which the pinions revolve.

7. The sprocket, or driving-gear, is attached directly to the differential case and drives the differential pinion-studs or axles.

8. The number of bevel-gear pinions composing a differential gear varies; usually three and sometimes four are used.

9. Each of the bevel-gear pinions are in mesh with and drive both gears attached to the rear axles.

10. There are three pinions used to more evenly distribute the strain.

11. When a car is traveling in a straight line and the resistance on both wheels is equal, the

(For questions to answers on this page, see p. 34.)

power is equally distributed between and drives both wheels.

12. When making a turn the wheel describing the smaller circle has considerable more resistance upon it than the other, therefore the power is transferred to the wheel of least resistance by the operation of the differential.

13. In the spur-gear type of differential there are three or more pairs of spur-pinions.

14. It is necessary to have spur-pinions in a differential run in pairs in order to drive the axle and secure the differential motion.

15. The spur-gears, like the bevel-gears, are attached to the ends of the rear axle and are in mesh with the spur-pinions.

16. Should one wheel be prevented from turning, the other one would turn as fast again as it would were both turning. The reason for this is that as the sprocket, or driving-gear, completes one turn, the bevel or spur pinions would also turn around the gear which remains stationary, and as the direction of rotation of the pinion in mesh with the other gear is opposite to the direction of the casing, this gear and consequently the wheel would be forced through another revolution by the pinions, thus making two revolutions of the driven wheel to one revolution of the sprocket, or driving-gear.

17. In turning curves, the outside wheel is

(For questions to answers on this page, see pp. 34, 35.)

driven, being the wheel offering the least resistance.

18. Should both wheels be raised from the floor and one wheel turned, the other would revolve in the opposite direction because in the case of a bevel-gear differential the driving-gear (that is the one attached to the wheel which you are turning) drives the pinion in the opposite direction to which it is turned. The pinion going in the opposite direction carries with it the gear in mesh with it, which is attached to the other wheel. In the case of a spur-gear differential, the driving-gear turns the spur-pinion in mesh with it in the opposite direction. This pinion turns the other pinion of the pair in the same direction as the driving-gear, and turns the gear attached to the other wheel in the opposite direction.

19. The action of the differential can be illustrated by Fig. 42, in which A1, A2 are two racks (straight gears) which are free to slide up and down. B is a pinion-gear in mesh with each of them. WW are weights placed on each rack, being each of the same weight. C is a handle journaled in the pinion B. Now if the pinion B were raised by means of the handle, racks A1, A2 would be lifted and B would not turn. This is exactly what happens when an automobile is traveling a straight, smooth road and the resistance is equal

(For questions to answers on this page, see p. 35.)

on both wheels. Now should one weight be removed from A2 (Fig. 43) and the pinion again lifted by its handle, the rack without the weight would be lifted and gear B would turn. If gear B is raised 1 inch, rack A2 would be raised 2 inches because the handle C, carrying with it pinion B, has been raised 1 inch and B also has turned and raised rack A2 by so turning. This is what happens when an automobile turns a corner or the resistance on one wheel is greater than that on the other.

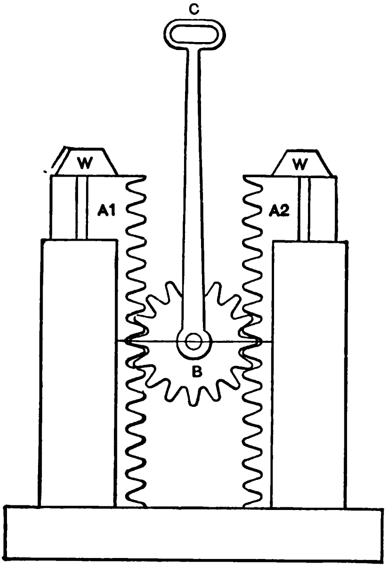


FIG. 42.—Illustrating the action of a differential gear in driving a straight smooth road.

(For questions to answers on this page, see p. 35.)

20. In traveling over ordinary roads the differential gears are never idle, because a straight line is not kept for any length of time, and every hollow or little hill which one wheel travels over increases or decreases the resistance on that wheel; for this reason lubrication and careful attention to adjustment should be given to the differential gearing.

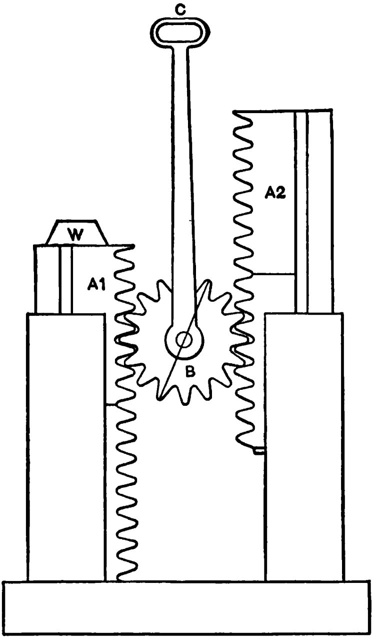


Fig. 43.—Illustrating the action of a differential gear in turning.

(For questions o answers on this page, see p. 35.)

TIRES

1. The casing of a clincher tire is made up of a number of layers of fabric joined by a thin coating of rubber. After putting a covering of rubber over the whole, the casing is cured by the vulcanizing process.

2. Inner tubes are made, upon a mandrel of the proper size, out of sheet rubber that has been partly cured. The edges are joined together, forming a tube, after which they are vulcanized.

3. Vulcanizing is a process of curing or toughening rubber of different compounds by the application of heat.

4. Acid vulcanizing is a form of curing a specially prepared rubber solution by which two pieces of vulcanized rubber may be attached. There is on the market a preparation which can be purchased and used very successfully by owners and drivers to repair small cuts on the outer case without removing the tire from the rim, and also to repair inner tubes. No great skill is needed in this work, and the results are very satisfactory.

5. That part of the tire which confines the inner tube and sustains the air pressure is called the shoe or casing.

6. The process of retreading a tire is to remove the outer rubber, sometimes taking as

(For questions to answers on this page, see p. 35.)

well the first layer of fabric, fitting a new covering of rubber and curing it by the vulcanizing process.

7. By gripping the clinch of a shoe on opposite sides with the fingers of each hand and pressing the thumbs into the sides just above the tread (Fig. 44) where the tire makes contact with the road you can determine if the fabric of which the tire is composed is separated. If it is soft, retreading will not be worth while.

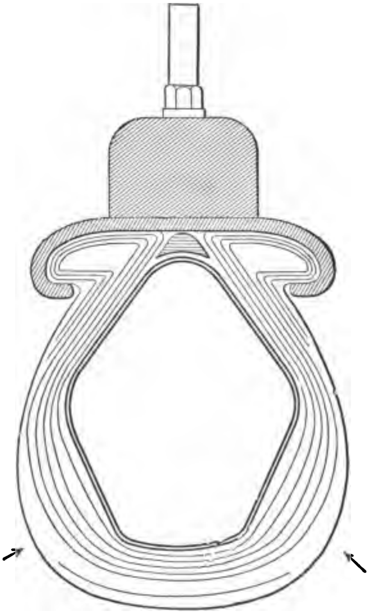


FIG. 44.—Illustrating separated tire fabric.

(For questions to answers on this page, see p. 35.)

8. Separation of the fabric, causing heating, is the result of too little pressure in a tire (Fig. 44).

9. The objection to overinflation of tires is that a great deal more of the vibration due to uneven surfaces of the road is transmitted to the frame and springs of the car, resulting in crystallization of the metal of which they are composed.

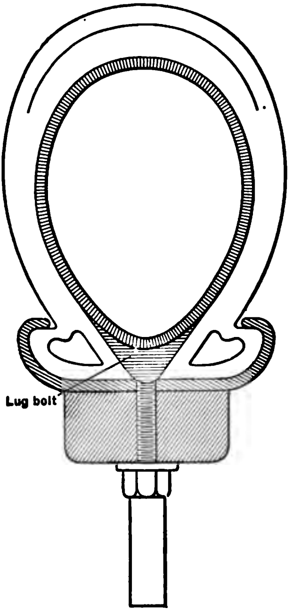


Fig. 45.—Tire properly in place on the rim.

(For questions to answers on this page, see p. 35.)

10. The causes of rim-cutting are: Too little air pressure, too rapid driving around curves, rough edges on the rims, and imperfect rims and tires (Fig. 45).

11. Tire-rims should be smooth and free from rust in order to make the removal of the shoe easy and to prevent chafing. The rim should be sand-papered inside and a coat of shellac or paint should be applied once or twice each season.

12. Heating of tires is caused by the friction of one layer of fabric against another, due to too little pressure per square inch.

13. By having a pressure gauge with an attachment that will open the tire-valve and hold it open, the pressure of a tire can be gauged. If the valve is not held open the pressure necessary to open the valve will be greater than the pressure within the tire, and the correct pressure within the tire is hard to determine without such a contrivance.

14. By reference to the following table the air pressures for different sizes of tires and weights of cars can be ascertained, and by keeping the pressure within the tire and on all four tires correct according to the respective weights the tires will last much longer than otherwise.

(For questions to answers on this page, see pp. 35, 36.)

TABLE OF WEIGHTS AND PRESSURES.

Size Tire.	Weight of Half of Car.	Pounds Pressure in Front Tires.	Multiplied by 1¼ Equals Pressure on Rear Tires.
3″	600 lbs.	60 lbs.	75 lbs.
	700 "	65 "	81¼ "
	800 "	70 "	87½ "
3½″	900 "	60 "	75 "
	1000 "	65 "	81¼ "
	1100 "	70 "	87½ "
4″	1200 "	60 "	75 "
	1300 "	65 "	81¼ "
	1400 "	70 "	87½ "
4½″	1500 "	60 "	75 "
	1600 "	65 "	81¼ "
	1700 "	70 "	87½ "
5″	1800 "	60 "	75 "
	2000 "	65 "	81¼ "
	2250 "	70 "	87½ "
	2500 "	75 "	93¾ "

15. When the car is standing on the garage floor without passengers, if the tires show any increase in size where they rest upon the floor they are not hard enough.

16. If in a hurry a fairly good test of tire inflation can be made by standing on the hub of each wheel. If you are a 200-pound man and the tire increases in size more than half an inch it is not hard enough.

17. Bunches, or protuberances, on the side of

(For questions to answers on this page, see p. 36.)

a tire, commonly called blisters, are caused either by sand working in through a cut and collecting in one or more places or by the separation and granulation of the rubber which is between each layer of fabric.

18. Cuts and bruises in the outer casing of a tire should be cemented up to prevent sand from working in and chafing the fabric and water from rotting the fabric.

19. The cause of the separation of the fabric is usually too little pressure. The action of a tire in rolling over the road is similar to rolling a sheet of music by starting at the free ends of the sheet.

20. In driving rapidly and striking a stone or other obstruction on the road, and not having sufficient air pressure to sustain the shock, the case is driven down to the rim with such force that the fabric of which the tire is composed is fractured. The outer covering of rubber having considerable more resiliency than the fabric may not be fractured and show no sign of what has happened inside.

21. A fabric fracture of the outer casing will open up and allow the inner tube to enter. Each time that the wheel revolves the opening closes on the inner tube, pinching it. In a short time the inner tube will leak. The only way to overcome this is to have the outer shoe patched inside.

(For questions to answers on this page, see p. 36.)

22. Frictioned duck is canvas impregnated with a rubber preparation.

23. The tire manufacturers state that the mileage of their tires will approximate 3,500 miles.

24. Upon the driver of an automobile the wear upon the tires depends to a greater extent than most of them are willing to admit. The sudden application of a brake brings a greater strain upon the rear tires than many miles of driving. Rapidly rounding a curve also brings a severe strain upon them, which is alike on front and rear tires. The front tires are strained in rounding a curve because the change in direction depends upon the traction of the front tires upon the road. Insufficient inflation is one of the worst evils that tire-makers have to contend with. The repair of surface cuts will exclude water and sand and prevent the fabric from rotting. In fact it is "up to you" whether you secure 1,000 or 5,000 miles from your tires.

25. When the clutch takes hold too quickly either the motor is stalled or the wheels slip around on the road. Should there be a sharp stone under the tire the tread would be cut by the slipping action.

26. When you get a puncture do not run on a deflated tire a foot or the tire will be ruined. A tire of the clincher variety held in place by lug-bolts cannot creep around the rim, and as

(For questions to answers on this page, see p. 36.)

the wheel travels over the road the tire is wrinkled and the fabric will be cut through. A half mile of such traveling will completely ruin a tire costing anywhere from $25 to $100.

27. A blow-out is a fracture in the case and inner tube not caused by cutting or puncture.

28. The cause of blow-outs is a gradual weakening of the fabric due to the separation and chafing of the same.

29. Spare tubes should be folded so that the valve-stem does not chafe against the folds. They should be packed securely in a pasteboard box so that they will not chafe, and carried where they will be free from oil. If they are packed loosely in a box the edges will chafe, and when they are needed perhaps will leak.

30. Should the tire-valve leak slowly without the cap on, in the majority of tire-valves a washer in the cap holds the air, and the check-valve within the stem is relieved when the cap is on, so that should the valve leak with the cap off there is no cause for alarm.

31. Should the rubber washer in the cap become lost do not attempt to cut a washer out of a piece of inner tube or sheet rubber, because the washer in the cap is cup-shaped, and good results are only obtained from a cup-shaped washer. The insides of tire-valves and spare washers for the caps should be carried as a part of the necessary equipment.

(For questions to answers on this page, see p. 36.)

32. In testing a tire-valve for leaks, by having the valve at the upper part of the wheel it can be immersed in a glass of water, which will show any air escaping by bubbling through the water. A method very often employed is to moisten the cap-washer with saliva, and when it is screwed in place bubbles will appear around it and through its top if it leaks.

33. Injecting a small quantity of oil into the valve to make it work easy has a directly opposite effect, and should never be done. The rubber in the valve-seat upon the application of oil will become so soft and swell so large as to effectually prevent air from being forced into the tire.

34. The covers used on spare tires carried for emergency, besides being sightly, keep the tire within them free from dust and dirt, moisture, light, and heat, any of which have a tendency to shorten the life of the casing. If you carry a spare shoe cover it with a waterproof covering.

35. In putting a car away for any length of time the wheels should be jacked up and the air pressure in the tire relieved, retaining only enough to keep the tire in its rounded form. The tire should then be covered to exclude the light and kept in a moderate and dry temperature.

36. In the process of manufacture the rubber

(For questions to answers on this page, see pp. 36, 37.)

is cured by heat, and if the process continues and they are soon over-cured, which means that the rubber has lost its life. Light also has a similar effect.

37. Oil has a softening effect upon tires and takes the life out of the rubber.

38. If oil gets on the tires it should be washed off with gasoline. Gasoline would have the same effect as the oil did it not evaporate so quickly.

39. The cause of a tire-wearing flat on the tread surface is incorrect alignment of the wheel, and instead of rolling over the road it is scraped along.

40. To detach a clincher tire from the rim, first release the air by inverting the valve-cap, and using it as a screw-driver, remove the inside of the valve; second, unscrew the nuts from the lug-bolts and valve-stem; third, starting opposite the valve and between two of the lug-bolts, pry the bead of the casing out of the rim with the tire-irons furnished for that purpose, pressing the lug-bolts into the tire as they are encountered.

41. When one side of the casing has been removed the inner tube can be drawn out, starting opposite the valve and working each way. The valve-stem can be removed by raising one side of the casing with the tire-iron. (See Fig. 46.)

(For questions to answers on this page, see p. 37.)

42. To remove the tire completely from the rim pry out the other bead, which will leave the casing still on the wheel, but detached from the clinch of the rim on both sides. Now pull the casing over the wheel and off, leaving the lug-bolts (if the nuts have not been entirely removed) loose in the rim.

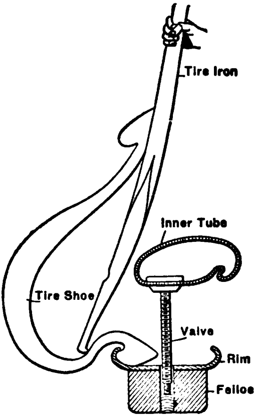


FIG. 46.—Raising the tire shoe to insert the valve-stem in the rim.

43. To assemble a clincher tire on the rim slip the shoe over the wheel and working from the side of the wheel nearest the car insert the bead in the clinch, pushing the lug-bolts in and out of the way as they are encountered. Insert the valve-stem in the hole in the rim by prying up the side of the shoe (Fig. 46) and tuck the tube

(For questions to answers on this page, see p. 37.)

in the tire, starting at the valve and working each way, taking care there are no folds or twists in it. Now inflate slightly (enough to give the tube a round form) and apply the other side of the shoe as follows: Push the valve-stem into the tire partly to allow the bead to enter the clinch, and when in place put the nut on the valve-stem to hold it there while the remainder of the shoe is being adjusted, taking care not to pinch the inner tube with the irons.

44. When the shoe is all in place push each lug-bolt into the tire and notice that the pressure of air in the tube returns them readily (Fig. 47). Should the lug-bolts not return when pushed in, it would indicate that the inner tube is caught between the head of the bolt and the side wall of the shoe (Fig. 48) and must be freed. When all of the lug-bolts are free try the valve-stem the same way and with the fingers screw up the nuts on the bolts and inflate the tire hard, reserving the final tightening of the nuts until the last.

45. When putting an inner tube in a shoe while on the road, instead of groping around inside the casing to find the valve-stem hole, pry one side of the tire up out of the way with the tire iron (Fig. 46), and after the valve-stem is in let it down again. Be careful the tire iron does not slip.

46. When inserting a new valve-stem in an

(For questions to answers on this page, see p. 37.)

inner tube put it away inside the tube-head first, then turn it around and put in through from the inside. The shoe of the valve will go through the hole easily if rubber cement is smeared over it.

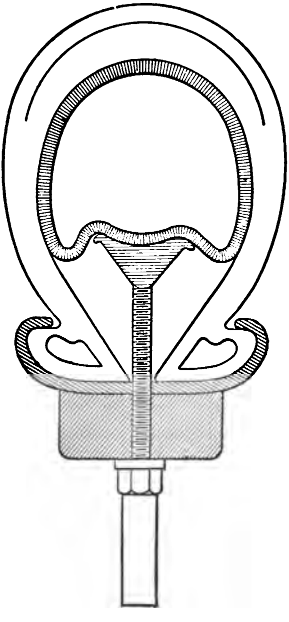


Fig. 47.—Pressing the lug-bolts into the tire to note if they are free.

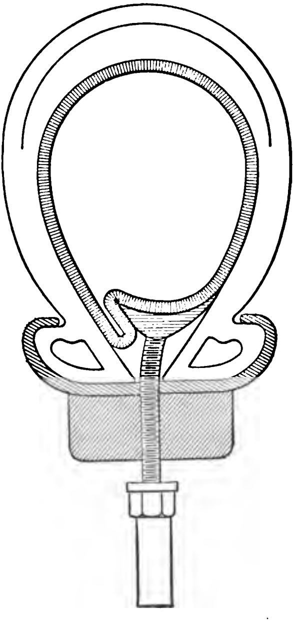


Fig. 48.—A pinched inner tube.

47. Patching an inner tube is an operation requiring considerable care and patience. The rubber surrounding the puncture must be

(For questions to answers on this page, see p. 37.)

thoroughly scraped with sandpaper and washed with gasoline to remove the bloom or sulphur before it is coated with cement and the patch must be treated likewise. The coating of cement should be applied evenly and allowed to dry fully twenty minutes. If the cement is thin a second and third coat must be applied to both tube and patch and each coating allowed to dry. When the cement is thoroughly dry the patch can be pressed firmly to the tube and the job is completed.

48. There are a number of patented rims on the market having the quick detachment of the tire as their object. These consist chiefly of two rings which slip over a rim on the wheel having suitable grooves or channels to receive them and are locked on by various methods, some of which consist of a turnbuckle to draw the ends of the ring together, thus causing it to grip the rim in the channel; springing a ring into a channel after the tire holding ring is in place and by locking the ends of the tire holding ring in suitable openings in the rim by means of a special tool furnished.

49. Other styles of rim are entirely detachable and do not necessitate the removal of the tire therefrom when punctured on the road, as a spare rim having a tire already inflated upon it can be attached and the punctured one repaired at leisure.

RACING THE ENGINE

(For questions to answers on this page, see p. 37.)

There is no practices indulged in by operators of automobiles so harmful as racing the engine and climbing hills that are too steep on the high gear. The strains which the piston connecting-rod, crank-shaft, and bearings are subjected to at excessively high speeds are enormous, and it is only due to the high class of workmanship, material, and design that the motors stand it at all. Just think what the effect would be on your shoulder if you threw a stone with anything like the force with which the piston is propelled in the cylinder. The effect is of the same nature although you may suffer no pain. When anything does break while the engine is racing the damage will be appalling.

Straining the engine by overloading, while not so injurious as racing, is nevertheless a practice which careful operators will not be guilty of. It is much better to reduce the gear than to weaken the engine by any such practice, and remember when in a low gear that racing the engine is worse than overloading it.

Five things denote a competent chauffeur—cleanliness, carefulness, watchfulness, readiness, and thoroughness:

A clean engine, car, and person.

Careful operation, taking no unnecessary risks.

Watching the road and the car.

(For questions to answers on this page, see p. 38.)

Ready at any time for emergencies while driving, and ready to start at a moment's notice.

Thorough in all mechanical work about the machinery, never leaving something to get better itself when there is time to spare.

TROUBLES

1. Should a chain break, cut out the broken link with a cold chisel, using a convenient stone wall for an anvil, and insert a spare link, which should always be carried on a chain-driven car.

2. Should a chain break on a car having double chain-drive, the sprocket on the jack-shaft carrying no chain would have to be fastened stationary in order to drive with one wheel. This could be done by fastening a stake between the spokes, holding the sprocket stationary.

3. Should a wheel be broken, bolt pieces of hard wood one inch thick on each side of the spokes, bearing at their middle against the hub, and at their outer ends under the tire rim. One hundred miles have been made numbers of times with this sort of repair.

4. Should a drive-shaft break, a temporary repair can be made by using a piece of steam-pipe, slipping it over the broken shaft and putting bolts or pins through holes drilled through the pipe and shaft.

(For questions to answers on this page, see p. 38.)

5. Should a spring break, the machine can be gotten to a blacksmith, where the spring can be repaired by jacking up the car and lashing a block of wood from some convenient woodpile between the spring and frame. Welded springs are hardly ever as good as new ones and a new spring should be ordered from the manufacturer without delay.

6. Should a fan-belt break and become lost do not worry. The fan is of no use in drawing the air through the radiator when traveling at high speed, and without the belt will go faster than it would were the belt driving it.

7. Should a fan be broken, it must be repaired upon arriving home with the same material of which it is made, because if lighter or heavier material is used it will throw the fan out of balance.

8. Should the pump break and could not be repaired on the road, take out the inside so as not to obstruct the free passage of water, or connect the pipe from the radiator to the cylinder-jacket without the pump.

9. Having a multicylinder engine, should the spark-plug break and none could be obtained, take out the plug and leave it out to relieve the compression. Stop the opening in the inlet-pipe to prevent the other cylinder from drawing air through it. Disconnect the wire from the timer or make contact to the engine

(For questions to answers on this page, see p. 38.)

with the secondary wire taken from the plug. It is necessary to form a complete circuit for the secondary current or disconnect the coil in order to avoid puncturing the spark-coil insulation.

10. Should a valve break on a multicylinder motor, take out the valve and proceed as for a broken spark-plug.

11. A spark-plug should not be screwed in too tight when the engine is cold for the reason that as the engine warms up the expansion of the metal is liable to break the porcelain insulator.

12. If the spark-plug is covered with soot or oil it is short-circuited and the secondary current, instead of jumping, will follow through the soot. If the spark-plug points are too near together the spark will not be hot (fat) enough to ignite the charge. Should the insulation be cracked, the spark will jump before it reaches the points and no spark will occur within the cylinder.

13. To tell when a spark-plug causes missed explosions, change the plug to another cylinder. If the missing follows the plug, the plug is at fault. If the plug works all right in that cylinder, the trouble should be looked for elsewhere.

14. Should a motor stop on a steep hill do not get excited. Back down the hill slowly. Get the motor going nicely and try again.

(For questions to answers on this page, see p. 39.)

15. Should the first speed-gear strip on a sliding-gear car be sure and take out the broken pieces of gear from the gear-box before attempting to run on the other gears.

16. Should a car start down a hill backwards through the brakes not being of sufficient power to hold it, if it is a sliding-gear car immediately throw in the reverse and let in the clutch easily. If the motor is going the car will not go any faster backwards than the motor will drive it. Should the motor be stopped, the car will stop also. If the low forward gear is used in backing down a hill it would have a tendency to turn the motor in the reverse direction when the clutch is engaged, and the gears are liable to strip from the shock. Having a planetary transmission apply the reverse as before, although usually a planetary transmission reverse is not as low as a sliding-gear reverse, so it might be necessary, if the car was heavily laden, to apply both low-speed and reverse when the engine stopped. Do not get excited, and do not let the car get under considerable headway before applying the reverse, as the gears are liable to strip and then you would have nothing to hold the car.

17. Should the vibrator refuse to work on one coil and the others are working, it proves that your battery current is all right and that the trouble is either at the timer or on that coil connection.

(For questions to answers on this page, see p. 39).

18. Should a vibrator stick at high speed it would indicate that the current strength entering the coil is too great for the condenser capacity, and as the heavy induced current of the primary winding is absorbed by the condenser the condenser would become full and discharge again, creating a continuous current and thus holding the vibrator down, or the battery current is not strong enough to overcome the tension of the vibrator-spring during the time of contact.

19. Should one of four cylinders stop firing and the vibrator on the coil work all right, disconnect the wire from the spark-plug, holding it ¼ of an inch from the spark-plug terminal, not more. Notice the spark-jump. If it jumps take out the plug and the trouble no doubt will be found there. (See Ans. No. 12.)

20. Should the carburetor spring a leak, a temporary repair can be made with sealing-wax.

21. Should a crack develop in the gasoline pipe leading from the tank to the carburetor, a temporary repair can be made by winding with electric tape, but this will not hold for any length of time and should be removed and the pipe soldered as soon as possible.

22. Should the cock in the gasoline pipe leak, it can be temporarily repaired by mixing some calcium plaster (plaster of paris) and covering the cock with it, winding a strip of cloth

around while the plaster is still wet to prevent the vibration from jarring off the plaster. This repair will hold for several days or until a new cock can be obtained.

23. Should the radiator leak badly the leaky spot can in a great many cases be temporarily repaired with calcium plaster.

24. Should the pump leak badly at the spindle, caused by worn packing, remove the stuffing-nut, and without taking out the old packing put in a piece of waste (if no packing is at hand) by winding around the spindle and screwing up the nut tightly.

25. Should the carburetor cough it indicates that either the inlet-valve has been held open or there is too light a mixture. (See Curburetor.)

26. Should the carburetor flood it indicates that the gasoline level is too high, caused perhaps by a grain of sand in the needle-valve attached to the float, or a float that has become partly filled with gasoline.

27. Should a metal float leak the opening can be found by immersing in hot water. The expansion of the air within as the float becomes heated would bubble up through the water, indicating the location of the fracture.

28. Should a knock be heard upon opening the throttle with a motor that is not too hot, the probable cause is too rich a mixture.

(For questions to answers on this page, see pp. 39, 40.)

This is more especially noticeable in engines having a high compression.

29. Should a knock be heard after traveling ten miles upon opening the throttle, or upon getting the engine heated, the probable cause is incandescent carbon on the cylinder or piston, prematurely firing the charge. Inject a gill of kerosene oil while the motor is hot. After turning the motor over 25 times, let it stand an hour and then remove the kerosene. Put in a teaspoonful of cylinder oil and start the motor. Repeated treatment of this sort will rid the piston and cylinder of carbon. Do not forget to oil after injecting kerosene.

30. Should the engine lose power, see that the valves are timed correctly. (See valves.) Notice the amount of compression. Or the cause may be lack of lubrication, incandescent carbon in the cylinder, a weak spark, a poor mixture, or friction in some of the bearings.

31. Should the motor skip on high speed and not on low speed the probable cause is a poor contact at the timer or a broken wire which, due to vibration, makes contact occasionally, or too much or too little current is entering the coil, causing the vibrator to stick. A poor mixture might also be the cause.

32. Should the motor skip on low speed with closed throttle and not skip on low speed with open throttle, as in ascending a hill or working

(For questions to answers on this page, see p. 40.)

hard, the probable cause will be a weak spring on the exhaust-valve or a leaky exhaust-valve.

33. Should the motor slow down when the throttle is opened quickly the drawing into the cylinder of an increased volume results in too rich a mixture, caused by the slow action of the carburetor, and it will be necessary to readjust the auxiliary air-valve.

34. Should the car travel along at a moderate speed, and when the throttle is opened and more speed attained the carburetor should cough, or, in other words, the motor explode through the carburetor, the cause is an insufficient supply of gasoline from tank to carburetor, causing the mixture to become too light when traveling fast.

35. Should the auxiliary air-valve on a carburetor stick and remain open, the motor could not be turned over fast enough by hand to draw gasoline. Close the auxiliary air-valve and try again.

36. Should the motor fail to start upon cranking, first listen for the vibrator buzzing. Second, prime the carburetor and look for the drip from it. Third, see that the throttle is not open too far. Fourth, test the compression. If the motor gets gas and a spark at the proper time it should run.

37. When a motor fails to start with two or three revolutions of the crank-shaft the best

(For questions to answers on this page, see p. 40.)

plan is to find out why; if the motor is getting gas which is not ignited in the cylinder it will be exhausted and fill the muffler. If the motor should start and the gas in the muffler become ignited from this explosion the muffler will be wrecked.

38. Should one cylinder miss explosions every other time with the throttle closed, the probable cause is a leaky valve or too weak an exhaust-valve spring.

39. Should the engine skip and pound when the throttle is opened, the probable cause is in the adjustment of the carburetor and the motor gets too rich a mixture when the throttle is opened.

40. Should the motor which had been skipping become overheated, the trouble is due to supplying the motor with a large quantity of gas to get the required power, and not getting the speed that should accompany that amount of gas. The remedy is to find the skip, keep the spark advanced, and use less gas.

41. Should the starting-crank be lost and the motor stopped at some distance from home before it had been discovered, the motor can be started by placing the transmission in high gear position, jacking up one rear wheel and turning it by hand. The next time the motor is stopped the car should be standing on a down grade, and when the brakes are

(For questions to answers on this page, see p. 41.)

released and the automobile gains headway, the high speed should be thrown in and the momentum of the car will turn over the motor.

42. Should the slow-speed or reverse band of a planetary transmission start the car with a jump it is because it grips the transmission-drum on all sides at once. To remedy this, bend the steel band at one point so as to form an irregular ring (Fig. 49). In this manner considerable pressure will be necessary upon the lever before the band conforms to the shape of the drum, thus stopping the drum gradually.

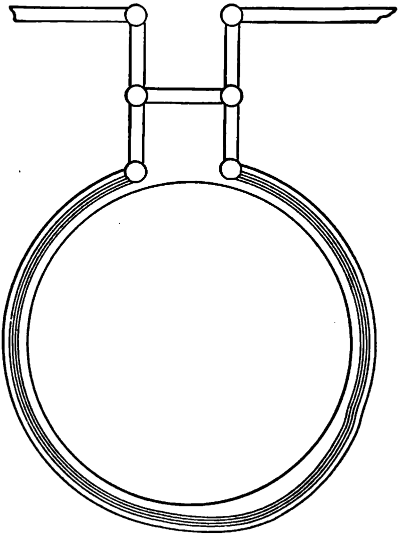


Fig. 49.—Bent transmission-band.

(For questions to answers on this page, see p. 41.)

43. Should one rear wheel become loose, the axle would turn around within the hub, and as the differential drives the wheel of least resistance, the car could not be propelled either backward or forward.

44. Should one rear wheel be mired, the other one having a good grip on the road, prevent the mired wheel from turning by holding with the hands and the power will be transferred to the other wheel.

45. If a storage-battery should lose its current quickly, it would indicate a short circuit. Look between each of the plates, where, perhaps, you will find something lodged. A test of the electrolyte will indicate whether the battery is run down or not. Should the electrolyte test all right, perhaps the terminal of the battery is broken away from the plates.

46. Should a storage-battery give a weak current after being charged, either it is short-circuited, sulphated, or has been charged in the reverse direction. (See Storage-batteries.)

47. Should a storage-battery case become broken or cracked through a fall, a temporary repair can be made by forcing hot sealing-wax into the facture, or if the break is extensive, a wooden box coated inside with paraffin can be used until a new jar can be obtained.

48. Should a rubber hose kink at a short bend, wind a close spiral spring of brass wire

(For questions to answers on this page, see p. 41.)

that will just fit inside of it, which will prevent it from kinking.

49. Should a tire shoe blow out and no spare shoe is at hand, put in the spare inner tube, wrapping your handkerchief around it at the position of the blow-out, then tie a piece of old leather shoe or some such material over the outside of the casing and inflate the tire, not too hard. This kind of repairing has done service many times.

50. The coating of rubber cement to patch an inner tube must not be hurried in drying. An hour, and perhaps more time, will be saved by letting the cement dry fully 25 minutes. Then press the patch and tube firmly together and inflate the tire hard. If the tire is not inflated tight enough it will heat and the patch will come off. Patches on inner tubes should be vulcanized or cured by the acid vulcanizing process.

51. If both sets of dry cells have not strength enough to run a car, test each cell by means of an ammeter, and selecting the best cells from both batteries, connect them into one battery.

Poor cells connected in series with good cells reduce the amperage of the whole battery.

52. Should dry cells give out, bore a hole in the top at least two inches deep and soak in water for half an hour. They will then have new life for a short time. Vinegar will make them stronger than water will.

(For questions to answers on this page, see pp. 41, 42.)

53. When attempting to change gears on a sliding-gear car, should the gears make a loud noise, one of several things is happening: either the clutch is not released, the speed of the car is greater than the speed of the motor, or the speed of the motor is greater than the speed of the car, or the clutch is dragging.

54. In backing a sliding-gear car, should the car be stopped and the reverse-gear be found to be locked in position, release the brakes slightly and move the car either backward or forward, at the same time shifting gears. The cause in this case is due to the small size of the reverse-gear, and having the strain of the car upon it, it prevents the sliding member from moving while the gears are not in motion.

55. In reducing gear, as from high to second speed, should the gears make a loud noise, the speed of the car has been too great for the speed at which the momentum carries the clutch. In order to overcome this the speed of the car should be reduced or the clutch should be let in and the engine speeded up before the gear-teeth will mesh properly.

56. Should the engine make a bumping noise and transmit a jerky motion to the car while going slowly, change to a lower gear. The gear you are running on is too high for the speed of the engine.

57. Should a motor give a few explosions

(For questions to answers on this page, see p. 42.)

and then stop and after the carburetor was primed it would start up again upon cranking, either the gasoline level is too low in the carburetor or something obstructs the opening in the spray-nozzle, preventing the gasoline from being drawn by the suction of the piston.

ALCOHOL

1. In the production of alcohol a number of agricultural products can be used, such as grain, potatoes, beets, etc. The amount of alcohol that can be produced per pound of mash varies with the quantity of sugar and starch contained in the material.

2. In the process of extracting alcohol from grain or vegetables several days are consumed, and while the owner of an automobile can produce the alcohol used for fuel, it is not as simple a process as some would have us believe, and it cannot be secured as easily as milk can be secured from a cow.

3. A simple process of extracting alcohol from potatoes is to boil them, crush to a pulp, and add enough water to make a thin mash. Stir in this mixture enough malt to start fermentation. This part of the process produces, or turns the starch into dextrine and maltose, and consumes several days' time. Now yeast should be added and the mixture left to fer-

(For questions to answers on this page, see p. 42.)

ment again, which converts the maltose into alcohol. The temperature during the fermenting process should be maintained not lower than 72 degrees F. or higher than 85 degrees F.

4. The process of distillation is accomplished by raising the temperature of the mass of fermented matter sufficiently to vaporize the alcohol and leave the water. In the first distillate water is carried with the alcohol in large amounts. Three subsequent distillations reduce the percentage of water to 16 per cent., which is as far as it is practicable to reduce it by this method.

5. Upon the percentage of water contained in the alcohol the power of the engine depends to a great extent, and as alcohol and water mix readily considerable difficulty is encountered in keeping the alcohol even 84 per cent. pure. Alcohol will absorb the moisture of the air readily, even reducing to 60 per cent. by this means.

6. The vaporization of alcohol for use in an internal-combustion engine depends upon several things: the temperature of the fuel and air, the moisture the air contains, the heat of the admission pipe, to prevent the condensation of the mixture, and the heat of the walls of the cylinder.

7. Ordinary gasoline carburetors can be used

(For questions to answers on this page, see p. 42.)

for alcohol fuel without change when the motor is hot, except to increase the per cent. of alcohol, but when the motor is cold considerable difficulty may be experienced in starting. A good way to start a cold motor on alcohol is to fill the water circulation with hot water, and thus heat the cylinders to begin with.

8. The power of alcohol mixtures as compared with gasoline mixtures is about the same, although an automobile that will travel twenty miles on one gallon of gasoline will not travel more than 16 miles on one gallon of alcohol with the same carburetor under different adjustments.

9. The alcohol used in explosive motors is commonly called "grain alcohol." Wood alcohol is not suitable as a fuel inasmuch that it has less heat during combustion, its vaporizing qualities are less, and it will be more expensive when the tax is raised from denaturized grain alcohol.

10. The constant temperature of the combustion-chamber walls must be greater in alcohol motors in order to secure the maximum power than in gasoline motors, and a test of the two fuels in the same car without changing the cooling system to meet the different requirements is not productive of the best results which can be obtained from alcohol.

MISCELLANEOUS

(For questions to answers on this page, see p. 43.)

1. Cape-cart or extension tops when folded back must be strapped securely to avoid any movement, otherwise the covering will chafe.

2. The Prest-o-lite gas-tank must not be put on the car with the cock which shuts off the gas lower than the center. The liquid in the tank will prevent the gas from reaching the lamps if he outlet from the tank is low enough.

3. A 25% solution of alcohol can be used in the gas-generator in winter to prevent freezing.

4. A single strand of wire from a piece of flexible electric-light cord or a battery connector can be used to clean out the acetylene-gas burners when they become stopped up.

5. Drill a hole in the horn on the under side of the bends a sixteenth of an inch in diameter to let out water which sometimes collects and prevents the "honk."

6. Turn the wicks of the kerosene lamps below the top of the burner when not in use to prevent the oil from being drawn up and covering the outside.

7. A jet of steam through a thirty-second-of-an-inch hole will clean all the oil and dirt from the engine and machinery quicker than anything I know of. Compressed air will do a good job too if steam is not handy.

(For questions to answers on this page, see p. 43.)

8. In grinding valves, a light spring placed under the head will raise it from its seat when the pressure is taken off. Do not use a heavy pressure in grinding valves or the seat is liable to be cut. The less pressure the better. If a valve has several deep pits in it, instead of grinding it on its seat an hour more or less, take the pits out on an emery wheel and it will save time.

9. Don't strain the steering-gear by turning the wheels while the car is not in motion; instead pull on the wheels at the same time the gear is turned.

10. When you want to stop at a house release your clutch in time for the car to come almost to a stop before applying the brake. In descending a hill use the motor as a brake. Save your brakes all you can. You may need them some time in an emergency.

11. Inflate both rear tires equally. Unequal pressure in rear tires imposes an unnecessary strain on the differential and makes it work overtime.

12. While inflating tires jack up the car and it will make the work easier by having less pressure to pump against.

13. The meaning of the horse-power rating, as 20–25, is that at the normal number of revolutions per minute the motor develops 20 H.P. When the speed increases 25 H.P. is produced.

(For questions to answers on this page, see p. 43.)

14. Horse-power ratings are of no value to the purchaser. On some cars where the reputation of the manufacturer is good, the horse-power is underrated to reduce taxes, tolls, etc., in others the horse-power is overrated to mislead the purchaser. Testing a car for ability is the only sure test. Hill-climbing qualities are sacrificed for speed in some cases, the reverse in other cases. A car that will show both qualities must have the power.

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